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# Responses of Tall and Semi-dwarf Spring Wheats to Levels of Nitrogen and Moisture Supply

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# RESPONSES OF TALL AND SEMI-DWARF SPRING WHEATS TO LEVELS OF NITROGEN AND MOISTURE SUPPLY

BY

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SUPPLY

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser Date

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# INTRODUCTION

Wheat is one of the principal cash crops in South Dakota, producing annually about 36,600,000 bushels on approximately 2,050,000 acres. Two of the major problems confronting wheat producers in this state are low yields and lodging.

High yielding semi-dwarfs from the International Maize and Wheat Improvement Center in Mexico offer breeders and producers in South Dakota short straw and high yielding ability. The semi-dwarfs promise to be better suited for irrigated production than tall varieties(26). Their performance under natural rainfall is of interest as well for most wheat acreage in South Dakota will not be irrigated.

The use of commercial fertilizers to increase yields of wheat has become an accepted practice in American agriculture. Nitrogen fertilizer must increase returns, either in grain yields or in protein content, if it is to be used profitably by wheat producers. Among nitrogenous fertilizers, ammonium nitrate possesses characteristics which make it suitable for use in mixed fertilizer and desirable for direct application to soils requiring only nitrogen.

High yields result from high fertility, weed and insect control, disease prevention, and use of adapted varieties. Soil moisture conditions also play an important role in seed production as well as in the protein content of wheat. Wheat production in some areas of this State is depressed by an inadequate supply of available nitrogen and soil moisture.

It is not enough to collect data from yield tests. They do not establish basic concepts. What happens in the test should be measured to reveal the basis for yield differences. The breeder is better able then to plan plant breeding programs.

The purposes of this study were to determine the responses of selected tall and semi-dwarf varieties grown under conditions of natural rainfall or irrigation at five levels of nitrogen fertilization and a constant high level of phosphorus fertilization. The characteristics studied were, namely, grain and straw yields, per cent protein in whole grain, yield of protein, seeds per head, weight of 200 seeds, heads bearing seeds in 60 cm. of row, number of seedlings in 60 cm. of row, plant height, per cent lodging, per cent fertility of main florets, and harvest index.

## REVIEW OF LITERATURE

The response of wheat varieties to changes in the environment has been studied often. Pope (19) in Texas noted that a response in seed yield was obtained only from nitrogen fertilizer on most of the clay loam soils. However, on fine sandy loam soils, wheat responded best to a combination of nitrogen and phosphorus fertilizers. Conversely, Murphy (13) at Stillwater, Oklahoma, found that neither nitrogen nor potash nor their combinations increased the yield of wheat on Kirkland sandy loam soil. Sexsmith and Russell (24) in studies at Stavely, Alberta, found that nitrogen or a combination of nitrogen and phosphorus fertilizers increased the yield of wheat on a shallow Lethbridge loam soil.

Burke (1), Neiding and Snyder (15) in Idaho concluded that soil moisture affected the yield and protein content of wheat. Fernández and Laird (3) at LaCal Grande, Mexico, found that the effect of applied nitrogen on grain yields was very largely dependent upon soil moisture conditions, but that the protein content of the grain was lowest in the wettest treatment and highest in the driest treatment. When moisture was adequate, increased yields of spring wheat grown on stubble fields in Southern Alberta were obtained from the use of nitrogen fertilizers (22). Fine <u>et al.</u> (4) found, at Redfield, South Dakota, that yields from irrigated wheat were only about 22% greater than from non-irrigated wheat when no fertilizer was applied. When fertilizer was applied, irrigation resulted in an average yield increase of 37%. Grafius and Dirks (6) found that hot, dry conditions reduced wheat yields in South Dakota. They also found that a late spring freeze in the seedling stage reduced yields by 22% due to stand reduction.

Leggett and Nelson (8) at Ritzville and Harrington, and Dusty, in Washington, noted that wheat yields were increased by the application of 20 pounds of nitrogen per acre at Ritzville, but 30 pounds of nitrogen per acre was the most effective at Harrington and Dusty. Nielson and Van Epps (17) suggested that 40 pounds of nitrogen per acre were adequate in an area where a yield response can be expected; the 60-pound rate was not superior to the 40-pound rate. This suggestion was supported by Eck _et al._ (2) and Nelson (16). Long _et al._ (10) and Wahhab and Hussain (27) found that 60 pounds of nitrogen applied at seeding time gave higher yield increases on irrigated wheat in West Pakistan than other rates or times of application, but on the High Plains, 80 pounds of nitrogen per acre was the most profitable rate to increase wheat yields (19). Applications of nitrogen up to 100 pounds per acre at seeding time increased wheat yields but did not provide sufficient nitrogen to increase protein content (11). The 200-pound rate of nitrogen caused a higher protein percentage than the 50- and 100- pound rates (12). However, Russell _et al._ (22) at Alberta, Canada, found that higher protein contents could be obtained from the application of 40 pounds of nitrogen per acre.

Sexsmith and Russell (24), Alberta, Canada, found that nitrogen fertilizer increased grain yields. The addition of phosphorus at the rate of 20 pounds per acre caused further yield increases, but sometimes reduced the effect of nitrogen on the protein content (22). In Tennessee, Long _et al._ (10) found that phosphorus fertilizer at the 60-pound rate produced yields significantly higher than those obtained from the 20-pound rate.

Height of wheat was unaffected by phosphorus fertilization but was increased by nitrogen fertilization (24). At LaCal Grande, Mexico, Fernández and Laird (3) indicated that straw yields were increased from 0.49 to 4.29 tons per acre in the wettest treatment and from 0.40 to 1.54 tons per acre in the driest treatment by the same application of nitrogen, 135 pounds per acre. Murphy (14) in Oklahoma found that phosphorus alone increased straw yields, that nitrogen alone had practically no effect, and that potash decreased straw yields.

In Texas, Pope (19) found that lodging often varied with soil fertility and moisture levels. Nelson (16) in Washington pointed out that lodging in general increased with increasing plant population and rates of nitrogen fertilization. However, regarding crop yield, Laude and Pauli (7) in Kansas concluded that when lodging occurred 1 to 2 weeks before heading, the decrease in yield averaged 30 to 35%. Lodging during the 5 days just prior to heading caused only half as much reduction in yield. When lodging occurred after heading, there were no changes in number of heads but the size of kernel was affected more than the number of kernels. The protein percentage was higher in grain from lodged than from standing wheat, but the total amount of protein per acre was less in areas of lodged than of standing wheat.

Grafius (5) pointed out that the yield of oats may be represented geometrically as a rectangular parallelepiped with edges being the number of panicles per unit area, the average number of kernels per panicle, and the average kernel weight. McNeal and Davis (11) in Montana noted that yield increases were the result of increasing the number of heads per unit area, the number of kernels per head, and kernel weight. Quisenberry (20) concluded that the number of heads per unit area was one of the most important factors in determining yield, the number of kernels per head was next in importance, while kernel weight was least important of the three.

In Illinois, Pendleton and Dungan (18) found that varieties did not react the same in grain yield to the different nitrogen applications and also found that the response of the short, early varieties was no greater than of the tall, late varieties. Wheat yields in Tennessee as well as quality of wheat and flour were influenced by nitrogen fertilization, particularly when applications were made late in the development of the plant (9). Yields in Alberta, Canada, were significantly increased by a high rate of nitrogen, and phosphorus additions resulted in further yield increases (22). In Mexico under different soil moisture conditions, when the amount of nitrogen was increased, grain yields increased at a gradually diminishing rate (3). In Oklahoma, Eck et al. (2) found that when adequate phosphorus was supplied, the application of nitrogen increased yields. Lack of phosphorus limited yields in some dryland areas of Utah (17). Racz et al. (21) at Winnipeg, Canada, determined that the addition of nitrogen or phosphorus did not appreciably increase the seed yield of wheat on the fallow plot, but on the nonfallow site nitrogen in combination with phosphorus significantly increased both seed and total yield of wheat. Murphy (14) in Oklahoma concluded that all fertilizers containing phosphorus gave higher grain yields than other fertilizer combinations. At the Ohio Agricultural Experiment Station, Wooster, complete fertilizer produced the highest yield (25).

The protein content of wheat seed was increased with increasing rates of nitrogen fertilizer, but phosphorus tended to decrease grain protein (14, 2, 25, 22). Burke (1) and McNeal et al. (12) in Montana observed that the plots containing the highest percentages of available nitrogen produced wheat of a higher protein content.

Studies conducted by the Experiment Station in Utah from 1942 through 1950 showed that nitrogen fertilizer increased both yield and protein content of wheat (17). Schlehuber et al. (23) in Oklahoma noted that both yield and protein content could be increased by timely application of adequate amounts of nitrogen fertilizer. Wheat yields were influenced by nitrogen fertilizer when applications were made late in the development of the plant (9). Long et al. (10) found that a split application--30 pounds at seeding and 30 pounds as a spring top dressing--was more effective than 60 pounds applied at seeding time.

# MATERIALS AND METHODS

The bread wheat varieties used were a tall variety, Chris, and two semi-dwarf varieties, Penjamo 62 and SDI 6623. The durum wheat varieties used were Leeds, which is tall, and two semi-dwarf varieties, SDI 669 and SDI 6617. The semi-dwarfs were developed by CIMMYT in Mexico.

Chris, CI 13751, was developed at the Minnesota Agricultural Experiment Station, St. Paul. Its characteristics are tallness, medium straw strength, beardlessness, high yielding ability, good milling and baking qualities, and high test weight. It has excellent resistance to leaf rust (_Puccinia recondita_ Rob. ex Desm.) and stem rust (_Puccinia graminis tritici_ Eriks & Henn.).

Penjamo 62 is a bearded, soft, red seeded, semi-dwarf variety. It possesses high yielding ability, high test weight, leaf rust and stem rust resistance, and undesirable milling and baking characteristics for the North Central area of the United States.

SDI 6623 has the pedigree Sonora 64 A x Selkirk E - Andes$^3$ E, II - 18883 - 6 M - 6 R - 6 C - 1 Y. It is a bearded, hard red semi-dwarf selection of high yielding ability, high test weight, and resistance to leaf rust and stem rust.

Leeds, C.I. 13768, has the pedigree (Langdon 357 x St 464 - Langdon 357) x Wells. It is a relatively tall, large seeded durum variety of early maturity, high yielding ability, and good leaf rust and stem rust resistance.

SDI 669 has the pedigree (Pitic 62 - St 464 x $Tehuacan_2$) x Lakota. It is a semi-dwarf durum selection with high yielding ability and high test weight. It is resistant to both leaf rust and stem rust.

SDI 6617 has the pedigree [(Yaktana 54 - N 104) x Langdon 357] x $Tehuacan_2$. It is a semi-dwarf durum of high yielding ability, good test weight, and resistance to leaf rust and stem rust.

Tests of germination made in March showed values of 96% for Penjamo 62 and SDI 6623, 71% for SDI 669, and 83% for SDI 6617. Certified seed of high germination was used of Chris and Leeds.

Each variety was grown under five rates of nitrogen, 0, 34, 67, 101, and 135 kg/ha (0, 30, 60, 90, and 120 pounds per acre), in the form of ammonium nitrate.

The experiments were conducted at two locations. The dryland test was located on the north side of the Plant Pathology Farm, South Dakota State University, Brookings, on Vienna loam soil. A soil test, made before the experiment was laid out, indicated poor nitrogen supplying ability of the soil, phosphorus at the high level of 85 kilograms per hectare, and potassium at a medium level of 209 kilograms per hectare. The pH was 6.7 and there was a low relative concentration of soluble salts. The texture of the soil is silt-loam. Heavy rain occurred on April 8. Light rain occurred on April 20, 25, 30, and May 2 ranging from 0.51 to 4.32 millimeters. Total June rainfall was 223 millimeters.

The irrigated test was located on the Redfield Development Farm at Redfield on Beotia silt loam. The soil test results indicated fair nitrogen supplying ability of the soil, a high rating for phosphorus of about 74 kilograms per hectare, 465 kilograms of potassium per hectare which was a very high level, pH 7.7, and low relative concentration of soluble salts. The texture of the soil is silt-loam.

A factorial experimental design with four replications was used. Each replicate consisted of five whole plots, one for each of five nitrogen treatments. The whole plot was 2.4 meters wide and 7.2 meters long including border rows. Border rows were seeded on the ends of the ranges. The size of the whole plot for purpose of application of nitrogen was 3.6 meters wide and 7.2 meters long. The whole plot was composed of six sub-plots, one for each variety. There were 3 rows thirty centimeters apart in each sub-plot.

Before seeding, 45 and 123 kilograms per hectare of phosphorus fertilizer were applied uniformly over the test areas at Brookings and Redfield, respectively. Five rates of nitrogen fertilizer were broadcast by hand, and then the land was plowed to turn under both phosphorus and nitrogen fertilizer.

The nurseries were seeded on April 4 at Brookings and May 8 at Redfield using a 4-row seeder mounted on an Allis Chalmers Model G tractor. The seeding rate was 4 grams per row or 55 kilograms per hectare. The only irrigation was made on July 12 at Redfield, thirty-seven days after seeding. Because of abundant rainfall over most of the season, a second irrigation was not necessary.

Septoria leaf spot (Septoria tritici) was controlled by spraying with Manzate D at the rate of 1.7 kilograms per hectare mixed well with a sticker-spreader (Triton - B - 1956) at the rate of 71 to 142 grams in 950 liters of water per hectare. At Brookings, it was sprayed on the test June 20 and 27 and on June 24, July 8, 17, and 26 at Redfield. Puritized Agricultural Spray at the rate of 0.6 liters in 950 liters of water per hectare was sprayed on June 12, 16, 20, and 27 at Brookings and on June 12, July 8, 17, and 26 at Redfield to prevent the occurrence of scab caused by Gibberella zeae. Arasan 42 - S (1:9) was sprayed on July 17 at Brookings and August 3 at Redfield to protect the heads from birds. Weeds were very severe at Redfield and were difficult to remove. At Brookings, dry conditions discouraged weed growth so little hand weeding was necessary.

Plant heights and percentages of lodging were noted before harvesting. The dates of harvest were July 27-28 at Brookings and August 11-12 at Redfield. Sixty centimeters of each middle row in each sub-plot marked with stakes early in the season was harvested first by digging the plants from the soil. Then another 120 centimeters in the same row was harvested. The characteristics studied from 60 cm. of row were grain yield, straw yield, number of heads bearing seeds, number of seeds per head, 200-seed weight, number of plants, number of tillers, protein yield, protein percentage from organic nitrogen based on the Kjeldahl method, and fertility of main florets. The characteristics studied from 180 cm. were grain yield, plant height, and lodging. Harvest index from 60 cm. of row was calculated from the formula:

$$\frac{\text{Weight of grain from 60 cm.}}{\text{Weight of straw and grain from 60 cm.}} \times 100.$$

English equivalents to the metric system used in this study are approximately:

2 inches = 5 cm.
15 bu./acre = 1,000 kg/ha

## RESULTS AND DISCUSSION

Complete data are presented in the appendix for heading dates, grain yields in 60 cm. and 180 cm. of row, number of tillers, number of heads bearing seeds, number of seeds per head, 200-seed weight, plant height, lodging, straw yield, harvest index, protein percentage, protein yield, and fertility of main florets. The same data, both as absolute values and in relation to the check values, are shown in line graph form in appendix figures.

### Dryland Test, Brookings

No rain fell for 60 days after seeding. Seedlings emerged about April 19, fifteen days after seeding. Heavy frosts occurred on April 24 and May 3 and 4, damaging some of the varieties. Minimum temperatures that occurred below 0°C. and the days of occurrence are shown below.

| Dates | Temperatures (°C.) |
|---|---|
| April 18 | -3.9 |
| " 19 | -3.3 |
| " 22 | -5.0 |
| " 23 | -5.0 |
| " 24 | -7.2 |
| May 2 | -5.0 |
| " 3 | -7.8 |
| " 4 | -8.3 |
| " 5 | -2.8 |
| " 6 | -3.3 |
| " 9 | -2.2 |
| " 14 | -1.1 |
| " 15 | -2.2 |
| " 16 | -0.6 |
| " 20 | -5.0 |

The number of plants in 60 cm. was noted on April 29 before frost damaged the stands and again after frost damage on May 13, thirty-nine days after seeding. In the second count, it was found that loss of seedlings from the frosts amounted to 6% of Chris, 5% of Penjamo 62, 4% of both SDI 6623 and Leeds, 25% of SDI 669, and 23% of SDI 6617. The latter two are the durum semi-dwarfs. Heading dates were not affected by nitrogen fertilizer (Appendix Table A-2). Table 1 evaluates mean squares from analyses of variance.

Among Bread Wheat Varieties

All comparisons between Chris and Penjamo 62, Chris and SDI 6623, and Penjamo 62 and SDI 6623 are shown in Tables 2, 3, and 4. The only significant mean square (Table 1) for rates of nitrogen was for the number of plants in 60 cm. which varied over varieties from 24 to 27 plants (Appendix Table A-1). Stand differences were unrelated to nitrogen rates. Varieties differed significantly in stands. Penjamo 62 had 96% germination in March but showed the lowest stand of the three bread wheats across nitrogen rates of 22 plants. Appendix Figure A-1 graphs stands in relation to nitrogen rates. No trends are apparent.

Nitrogen levels had no significant influence on the other variables studied. There were no significant mean squares for the interaction of nitrogen rates and varieties (NxV).

Varietal differences were significant for all characteristics studied except grain yields from 180 cm. and 60 cm. and per cent

Table 1. Significance of mean squares in analyses of variance for the dryland test, Brookings.

| Sources | df | Yield (kg/ha) straw (60 cm.) | Yield (kg/ha) seed (180 cm.) | Yield (kg/ha) seed (60 cm.) | Yield components No. heads with seeds (60 cm.) | Yield components No. seeds per head | Yield components 200-seed wt. (cg) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. in cm. | % lodging | Protein % | Protein yield (kg/ha) | % fertility of florets |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Bread wheat | | | | | | | |
| N rates(N) | 4 | NS | NS | NS | NS | NS | NS | * | NS | NS | NS | NS | NS | NS |
| Varieties(V) | 2 | ** | NS | NS | * | * | ** | * | ** | ** | ** | ** | * | NS |
| NxV | 8 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | | | | | | | Durum wheat | | | | | | | |
| N rates(N) | 4 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Varieties(V) | 2 | ** | NS | NS | ** | NS | ** | ** | NS | ** | ** | NS | NS | NS |
| NxV | 8 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

* - significant at 5% level
** - significant at 1% level
NS - not significant

Table 2. Chris and Penjamo 62 compared in the dryland test, Brookings.

| N rates kg/ha | Varieties | Yield (kg/ha) straw (60 cm.) | seed (180 cm.) | seed (60 cm.) | Components No. heads with seeds (60 cm.) | No. seeds per head | 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | Protein % | yield (kg/ha) | % fertility of florets | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check | Chris | 4317 | 2185 | 2254 | 62 | 25 | 535 | 26 | 69 | 77 | 4.50 | 15.05 | 339 | 98 | 34 |
| | Penjamo 62 | 3206 | 2034 | 2058 | 52 | 26 | 573 | 22 | 55 | 62 | 2.50 | 13.35 | 273 | 96 | 39 |
| 34(30)* | Chris | 3811 | 2276 | 2008 | 57 | 26 | 498 | 25 | 61 | 78 | 3.25 | 15.65 | 314 | 97 | 35 |
| | Penjamo 62 | 2910 | 2285 | 1953 | 50 | 26 | 565 | 24 | 55 | 60 | 1.75 | 13.45 | 264 | 96 | 40 |
| 67(60) | Chris | 3811 | 1889 | 1899 | 59 | 25 | 468 | 24 | 66 | 74 | 3.25 | 16.05 | 305 | 98 | 33 |
| | Penjamo 62 | 3033 | 2172 | 1953 | 48 | 27 | 550 | 25 | 52 | 57 | 1.75 | 13.95 | 270 | 97 | 39 |
| 101(90) | Chris | 3934 | 2194 | 1912 | 59 | 26 | 463 | 23 | 64 | 76 | 3.25 | 16.03 | 308 | 96 | 33 |
| | Penjamo 62 | 3005 | 2090 | 1926 | 48 | 28 | 543 | 22 | 52 | 58 | 1.75 | 13.75 | 264 | 96 | 39 |
| 135(120) | Chris | 3757 | 2121 | 1885 | 57 | 26 | 463 | 28 | 66 | 75 | 2.75 | 15.88 | 299 | 96 | 33 |
| | Penjamo 62 | 2773 | 2117 | 1858 | 44 | 29 | 523 | 19 | 46 | 60 | 1.75 | 13.83 | 256 | 98 | 40 |
| Mean | Chris | 3926 | 2133 | 1992 | 59 | 26 | 485 | 25 | 65 | 76 | 3.40 | 15.73 | 313 | 97 | 34 |
| | Penjamo 62 | 2985 | 2139 | 1950 | 48 | 27 | 551 | 22 | 52 | 59 | 1.90 | 13.67 | 265 | 97 | 39 |
| LSD.05 (varieties) | = | 219 | NS | NS | 4 | 2 | 21 | 3 | 4 | 1.5 | 0.26 | 0.034 | 22 | NS | - |
| C.V. (%) | = | 10.06 | 10.84 | 13.23 | 12.26 | 10.19 | 6.43 | 19.64 | 11.22 | 3.70 | 31.97 | 1.36 | 11.83 | 46.47 | - |

* lbs. per acre
NS - 'not significant'

Table 3. Chris and SDI 6623 compared in the dryland test, Brookings.

| N rates kg/ha | Varieties | Yield (kg/ha) straw (60 cm.) | Yield (kg/ha) seed (180 cm.) | Yield (kg/ha) seed (60 cm.) | Components No. heads with seeds (60 cm.) | Components No. seeds per head | Components 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | Protein % | Protein yield (kg/ha) | % fertility of florets | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check | Chris | 4317 | 2185 | 2254 | 62 | 25 | 535 | 26 | 69 | 77 | 4.50 | 15.05 | 339 | 98 | 34 |
| | SDI 6623 | 3155 | 2026 | 2076 | 57 | 29 | 460 | 30 | 60 | 53 | 1.50 | 14.50 | 298 | 95 | 40 |
| 34(30)* | Chris | 3811 | 2276 | 2008 | 57 | 26 | 498 | 25 | 61 | 78 | 3.25 | 15.65 | 314 | 97 | 35 |
| | SDI 6623 | 3128 | 2090 | 1858 | 56 | 28 | 443 | 31 | 60 | 54 | 0.75 | 14.55 | 270 | 95 | 37 |
| 67(60) | Chris | 3811 | 1889 | 1899 | 59 | 25 | 468 | 24 | 66 | 74 | 3.25 | 16.05 | 305 | 98 | 33 |
| | SDI 6623 | 3278 | 2153 | 2035 | 58 | 30 | 433 | 24 | 61 | 55 | 0.50 | 14.73 | 299 | 97 | 38 |
| 101(90) | Chris | 3934 | 2194 | 1912 | 59 | 26 | 463 | 23 | 64 | 76 | 3.25 | 16.03 | 308 | 96 | 33 |
| | SDI 6623 | 2992 | 2108 | 1885 | 52 | 28 | 468 | 26 | 54 | 55 | 0.50 | 14.60 | 275 | 97 | 39 |
| 135(120) | Chris | 3757 | 2121 | 1885 | 57 | 26 | 463 | 28 | 66 | 75 | 2.75 | 15.88 | 299 | 96 | 33 |
| | SDI 6623 | 2814 | 1871 | 1748 | 51 | 26 | 488 | 32 | 58 | 55 | 0 | 14.80 | 260 | 96 | 38 |
| Mean | Chris | 3926 | 2133 | 1992 | 59 | 26 | 485 | 25 | 65 | 76 | 3.40 | 15.73 | 313 | 97 | 34 |
| | SDI 6623 | 3073 | 2049 | 1920 | 55 | 28 | 458 | 29 | 59 | 54 | 0.65 | 14.64 | 280 | 96 | 38 |
| LSD.05 | (varieties)= | 219 | NS | NS | 4 | 2 | 21 | 3 | 4 | 1.5 | 0.26 | 0.034 | 22 | NS | - |
| C.V. | (%) | =10.06 | 10.84 | 13.23 | 12.26 | 10.19 | 6.43 | 19.64 | 11.22 | 3.70 | 31.97 | 1.36 | 11.83 | 46.47 | - |

* lbs. per acre

NS - 'not significant'

Table 4. Penjamo 62 and SDI 6623 compared in the dryland test, Brookings.

| N rates kg/ha | Varieties | Yield (kg/ha) straw (60 cm.) | Yield (kg/ha) seed (180 cm.) | Yield (kg/ha) seed (60 cm.) | Components No. heads with seeds (60 cm.) | Components No. seeds per head | Components 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | Protein % | Protein yield (kg/ha) | % fertility of florets | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check | Penjamo 62 | 3206 | 2034 | 2058 | 52 | 26 | 573 | 22 | 55 | 62 | 2.50 | 13.35 | 273 | 96 | 39 |
| | SDI 6623 | 3155 | 2026 | 2076 | 57 | 29 | 460 | 30 | 60 | 53 | 1.50 | 14.50 | 298 | 95 | 40 |
| 34(30)* | Penjamo 62 | 2910 | 2285 | 1953 | 50 | 26 | 565 | 24 | 55 | 60 | 1.75 | 13.45 | 264 | 96 | 40 |
| | SDI 6623 | 3128 | 2090 | 1858 | 56 | 28 | 443 | 31 | 60 | 54 | 0.75 | 14.55 | 270 | 95 | 37 |
| 67(60) | Penjamo 62 | 3033 | 2172 | 1953 | 48 | 27 | 550 | 25 | 52 | 57 | 1.75 | 13.95 | 270 | 97 | 39 |
| | SDI 6623 | 3278 | 2153 | 2035 | 58 | 30 | 433 | 24 | 61 | 55 | 0.50 | 14.73 | 299 | 97 | 38 |
| 101(90) | Penjamo 62 | 3005 | 2090 | 1926 | 48 | 28 | 543 | 22 | 52 | 58 | 1.75 | 13.75 | 264 | 96 | 39 |
| | SDI 6623 | 2992 | 2108 | 1885 | 52 | 28 | 468 | 26 | 54 | 55 | 0.50 | 14.60 | 275 | 97 | 39 |
| 135(120) | Penjamo 62 | 2773 | 2117 | 1858 | 44 | 29 | 523 | 19 | 46 | 60 | 1.75 | 13.83 | 256 | 98 | 40 |
| | SDI 6623 | 2814 | 1871 | 1748 | 51 | 26 | 488 | 32 | 58 | 55 | 0 | 14.80 | 260 | 96 | 38 |
| Mean | Penjamo 62 | 2985 | 2139 | 1950 | 48 | 27 | 551 | 22 | 52 | 59 | 1.90 | 13.67 | 265 | 97 | 39 |
| | SDI 6623 | 3073 | 2049 | 1920 | 55 | 28 | 458 | 29 | 59 | 54 | 0.65 | 14.64 | 280 | 96 | 38 |

* lbs. per acre

fertility of main florets. Over rates of nitrogen, Chris produced significantly higher straw yields than Penjamo 62 by 941 kg/ha (Table 2) and SDI 6623 by 853 kg/ha (Table 3) because it was taller and produced more tillers. Tiller number was usually higher in the check treatment than for the other rates of nitrogen, but there was no significant interaction. Chris averaged 13 more tillers in 60 cm. than Penjamo 62 and 17 cm. greater height. Chris averaged 16 more tillers in 60 cm. than SDI 6623 and 22 cm. greater height. Penjamo 62 averaged 7 fewer tillers than SDI 6623 and 5 cm. greater height but these two semi-dwarfs had the same yield of straw (Table 4).

Grain yields did not differ significantly among varieties under conditions of drouth stress, but yield components did differ significantly. Average grain yields over five rates of nitrogen for Chris was 1992 kg/ha and for Penjamo 62 was 1950 kg/ha (Table 2). At any rate of nitrogen, Chris was higher in the number of heads bearing seeds but lower than Penjamo 62 in 200-seed weight. So, these two components seemed to compensate for one another. The numbers of seeds per head of both varieties were similar. Chris was a little higher in grain yield than SDI 6623 (Table 3) but not significantly so. Chris averaged 59 heads and SDI 6623 55 heads in 60 cm., not a significant difference. Chris was not significantly higher in 200-seed weight than SDI 6623 over rates of nitrogen. However, Chris tended to have larger seeds at lower rates of nitrogen than SDI 6623. SDI 6623 had more seeds per head

Table 5. Leeds and SDI 669 compared in the dryland test, Brookings.

| | | Yield (kg/ha) | | | Components | | | | | | | | Protein | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N rates kg/ha | Varieties | straw (60 cm.) | seed (180 cm.) | seed (60 cm.) | No. heads with seeds (60 cm.) | No. seeds per head | 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | % | yield (kg/ha) | % fertility of florets | Harvest index (%) |
| Check | Leeds | 3716 | 2099 | 2076 | 45 | 25 | 673 | 23 | 51 | 74 | 1.00 | 14.83 | 306 | 92 | 36 |
| | SDI 669 | 3716 | 2090 | 2117 | 44 | 26 | 688 | 19 | 51 | 55 | 0.50 | 15.03 | 319 | 88 | 36 |
| 34(30)* | Leeds | 3784 | 2035 | 1994 | 45 | 25 | 663 | 23 | 51 | 74 | 1.00 | 16.05 | 320 | 92 | 35 |
| | SDI 669 | 3442 | 2263 | 1981 | 39 | 28 | 680 | 15 | 46 | 57 | 0.25 | 15.08 | 298 | 89 | 37 |
| 67(60) | Leeds | 4043 | 1962 | 2090 | 46 | 26 | 648 | 24 | 54 | 72 | 1.25 | 16.38 | 339 | 90 | 34 |
| | SDI 669 | 3893 | 2076 | 2172 | 48 | 26 | 645 | 22 | 57 | 55 | 1.25 | 15.43 | 332 | 91 | 36 |
| 101(90) | Leeds | 4194 | 2354 | 2199 | 47 | 26 | 668 | 29 | 55 | 72 | 2.00 | 16.48 | 362 | 92 | 34 |
| | SDI 669 | 3606 | 2604 | 1994 | 37 | 30 | 683 | 14 | 44 | 57 | 0.25 | 15.08 | 299 | 88 | 36 |
| 135(120) | Leeds | 3647 | 2049 | 1981 | 41 | 27 | 663 | 24 | 49 | 72 | 1.50 | 16.48 | 325 | 90 | 35 |
| | SDI 669 | 3866 | 2276 | 2268 | 45 | 28 | 675 | 19 | 57 | 56 | 1.00 | 15.08 | 343 | 93 | 37 |
| Mean | Leeds | 3876 | 2099 | 2068 | 45 | 26 | 663 | 25 | 52 | 73 | 1.35 | 16.04 | 330 | 91 | 35 |
| | SDI 669 | 3705 | 2261 | 2106 | 43 | 28 | 674 | 18 | 51 | 56 | 0.65 | 15.14 | 318 | 90 | 36 |
| LSD.05 (varieties)= | | 297 | NS | NS | 4 | NS | 18 | 3 | NS | 1.5 | 0.3 | NS | NS | NS | - |
| C.V.(%) | | =12.35 | 14.38 | 14.64 | 14.00 | 11.15 | 4.14 | 22.14 | 15.65 | 3.77 | 54.76 | 15.50 | 45.97 | 19.32 | - |

* lbs. per acre
NS - 'not significant'

Table 6. Leeds and SDI 6617 compared in the dryland test, Brookings.

| N rates kg/ha | Varieties | Yield (kg/ha) straw (60 cm.) | seed (180 cm.) | seed (60 cm.) | Components No. heads with seeds (60 cm.) | No. seeds per head | 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | Protein % | Protein yield (kg/ha) | % fertility of florets | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check | Leeds | 3716 | 2099 | 2076 | 45 | 25 | 673 | 23 | 51 | 74 | 1.00 | 14.83 | 306 | 92 | 36 |
| | SDI 6617 | 3224 | 2085 | 1981 | 42 | 27 | 643 | 19 | 49 | 52 | 0.50 | 14.73 | 292 | 91 | 38 |
| 34(30)* | Leeds | 3784 | 2035 | 1994 | 45 | 25 | 663 | 23 | 51 | 74 | 1.00 | 16.05 | 320 | 92 | 35 |
| | SDI 6617 | 3265 | 2249 | 2090 | 41 | 29 | 635 | 17 | 47 | 56 | 0.75 | 14.85 | 310 | 92 | 39 |
| 67(60) | Leeds | 4043 | 1962 | 2090 | 46 | 26 | 648 | 24 | 54 | 72 | 1.25 | 16.38 | 339 | 90 | 34 |
| | SDI 6617 | 3374 | 2058 | 2063 | 44 | 28 | 613 | 21 | 53 | 53 | 1.00 | 15.15 | 313 | 93 | 38 |
| 101(90) | Leeds | 4194 | 2354 | 2199 | 47 | 26 | 668 | 29 | 55 | 72 | 2.00 | 16.48 | 362 | 92 | 34 |
| | SDI 6617 | 3620 | 2413 | 2350 | 48 | 28 | 638 | 20 | 53 | 54 | 2.00 | 14.93 | 351 | 92 | 39 |
| 135(120) | Leeds | 3647 | 2049 | 1981 | 41 | 27 | 663 | 24 | 49 | 72 | 1.50 | 16.48 | 325 | 90 | 35 |
| | SDI 6617 | 3688 | 2504 | 2336 | 47 | 28 | 635 | 22 | 59 | 54 | 0.75 | 15.30 | 357 | 92 | 39 |
| Mean | Leeds | 3876 | 2099 | 2068 | 45 | 26 | 663 | 25 | 52 | 73 | 1.35 | 16.04 | 330 | 91 | 35 |
| | SDI 6617 | 3434 | 2261 | 2164 | 44 | 28 | 633 | 20 | 52 | 54 | 1.00 | 14.99 | 325 | 92 | 39 |
| LSD.05 (varieties)= | | 297 | NS | NS | 4 | NS | 18 | 3 | NS | 1.5 | 0.3 | NS | NS | NS | - |
| C.V.(%) | | =12.35 | 14.38 | 14.64 | 14.00 | 11.15 | 4.14 | 22.14 | 15.65 | 3.77 | 54.76 | 15.50 | 45.97 | 19.32 | - |

* lbs. per acre
NS - 'not significant'

Table 7. SDI 669 and SDI 6617 compared in the dryland test, Brookings.

| N rates kg/ha | Varieties | Yield (kg/ha) straw (60 cm.) | seed (180 cm.) | seed (60 cm.) | Components No. heads with seeds (60 cm.) | No. seeds per head | 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | Protein % | yield (kg/ha) | % fertility of florets | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check | SDI 669 | 3716 | 2090 | 2117 | 44 | 26 | 688 | 19 | 51 | 55 | 0.50 | 15.03 | 319 | 88 | 36 |
| | SDI 6617 | 3224 | 2085 | 1981 | 42 | 27 | 643 | 19 | 49 | 52 | 0.50 | 14.73 | 292 | 91 | 38 |
| 34(30)* | SDI 669 | 3442 | 2263 | 1981 | 39 | 28 | 680 | 15 | 46 | 57 | 0.25 | 15.08 | 298 | 89 | 37 |
| | SDI 6617 | 3265 | 2249 | 2090 | 41 | 29 | 635 | 17 | 47 | 56 | 0.75 | 14.85 | 310 | 92 | 39 |
| 67(60) | SDI 669 | 3893 | 2076 | 2172 | 48 | 26 | 645 | 22 | 57 | 55 | 1.25 | 15.43 | 332 | 91 | 36 |
| | SDI 6617 | 3374 | 2058 | 2063 | 44 | 28 | 613 | 21 | 53 | 53 | 1.00 | 15.15 | 313 | 93 | 38 |
| 101(90) | SDI 669 | 3606 | 2604 | 1994 | 37 | 30 | 683 | 14 | 44 | 57 | 0.25 | 15.08 | 299 | 88 | 36 |
| | SDI 6617 | 3620 | 2413 | 2350 | 48 | 28 | 638 | 20 | 53 | 54 | 2.00 | 14.93 | 351 | 92 | 39 |
| 135(120) | SDI 669 | 3866 | 2276 | 2268 | 45 | 28 | 675 | 19 | 57 | 56 | 1.00 | 15.08 | 343 | 93 | 37 |
| | SDI 6617 | 3688 | 2504 | 2336 | 47 | 28 | 635 | 22 | 59 | 54 | 0.75 | 15.30 | 357 | 92 | 39 |
| Mean | SDI 669 | 3705 | 2261 | 2106 | 43 | 28 | 674 | 18 | 51 | 56 | 0.65 | 15.14 | 318 | 90 | 36 |
| | SDI 6617 | 3434 | 2261 | 2164 | 44 | 28 | 633 | 20 | 52 | 54 | 1.00 | 14.99 | 325 | 92 | 39 |

* lbs. per acre

over nitrogen rates nor were there any significant interactions between nitrogen rates and varieties (NxV).

Among varieties highly significant differences were obtained for straw yield, number of heads bearing seeds, 200-seed weight, number of plants, plant height, and per cent lodging. Leeds and the two semi-dwarfs averaged 25, 18, and 20 plants respectively. The lower stands of the semi-dwarfs were partly a frost effect as noted earlier. Differences in straw yield were small even though Leeds was 17 cm. (Table 5) to 19 cm. (Table 6) taller than the semi-dwarfs and had significantly more plants. Mean numbers of tillers were the same. While mean stands favored Leeds, it had no more total tillers. Therefore, Leeds tillered less per plant than either semi-dwarf. However, the two durum semi-dwarfs had a greater chance to tiller because of reduced stands. SDI 6617 yielded less straw than Leeds at the four lowest rates of nitrogen but at the highest rate it equaled Leeds in straw yield due to a higher rate of tillering. This also was true at Redfield under irrigation. Leeds had two less tillers at the 135 kg/ha rate of nitrogen than it did at the check level while SDI 6617 had ten more tillers at the highest rate of nitrogen than at the check level. Average tillers per plant at the highest rate of nitrogen were 2.0 for Leeds and 2.7 for SDI 6617. Leeds and SDI 6617 were similar in grain yield over rates of nitrogen. Leeds had larger seed and fewer seeds per head which tended to compensate for one another. SDI 6617 averaged about 10% more grain yield over the two highest rates of nitrogen.

Grain yields and the number of seeds per head did not differ significantly, but the number of heads bearing seeds and weights of 200 seeds did differ significantly. Yields of grain were 2068 kg/ha for Leeds and 2106 kg/ha for SDI 669 (Table 5). Leeds averaged only two more heads than SDI 669. Differences in the number of heads bearing seeds were significant only at the 34, 101, and 135 kg/ha rates. At the check level and the 67 kg/ha rate, the durums were much alike. Leeds and SDI 669 were similar in 200-seed weight but both were significantly larger seeded than SDI 6617.

The durums differed significantly in lodging, with Leeds lodging the most. Lodging was never higher than 2% over replicates.

The harvest indexes, not influenced by increasing rates of nitrogen, averaged 35% for Leeds, 36% for SDI 669 (Table 5), and 39% for SDI 6617 (Table 6). The highest harvest index of SDI 6617 made no apparent difference in yield of grain.

Correlation values are shown in Table 8. Yields of straw and grain were highly correlated for all comparisons within individual plots, meaning that yields of straw and grain tended to vary together. In Table 1, the mean square was not significant for grain yields but was significant for straw yields among varieties. No statistical measure of these relationships was made because only three varieties of each class of wheat were involved. However, the mean squares for grain yield were not significant for either class of wheat. So it has not been shown in this experiment that high grain yields and low straw yields go together. Both the

Table 8. Correlation values for individual observations for some of the characteristics measured at the dryland test, Brookings.

| Class of wheat | Hgt. | df | Grain vs straw | Grain vs 200-seed wt. | Grain vs heads with seeds | Grain vs seeds per head | Straw vs 200-seed wt. | Straw vs heads with seeds | Straw vs seeds per head | 200-seed wt. vs heads with seeds | 200-seed wt. vs seeds per head | Heads with seeds vs seeds per head |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bread | All | 58 | 0.66** | 0.33* | 0.51** | 0.43** | -0.01 | 0.77** | -0.05 | -0.30* | -0.08 | -0.26* |
| Durum | All | 58 | 0.81** | 0.16 | 0.63** | 0.48** | 0.26* | 0.63** | 0.16 | -0.36** | 0.22 | -0.29* |
| Both | Tall | 38 | 0.91** | 0.37* | 0.21 | 0.54** | 0.17 | 0.40** | 0.39* | -0.69** | 0.17 | -0.28 |
| Both | Semi-dwarf | 78 | 0.82** | 0.35** | 0.38** | 0.45** | 0.45** | 0.31** | 0.15 | -0.58** | -0.03 | -0.12 |

* - significant at 5% level
** - significant at 1% level

number of heads bearing seeds and the number of seeds per head were highly associated with grain yield in both bread wheat and durum wheat varieties. Weight of 200 seeds showed a significant positive association with grain yield for all the combined bread wheat varieties and for the two tall and four semi-dwarf varieties but not for combined heights of durum wheat varieties. Among semi-dwarf varieties, 200-seed weight, number of heads bearing seeds, and number of seeds per head showed highly positive associations with grain yield. Figures 1 and 2 give a graphic representation of the response of yields and its components to changes in rates of nitrogen of two tall and four semi-dwarf varieties.

Since the correlation between grain yield and 200-seed weight was significant for the bread wheats but not the durums, we know that 200-seed weight also varied and was a factor in determining bread wheat yields but was of less importance in the durums than number of seeds per head and number of heads bearing seeds.

Of the three components of yield, number of seeds per head was least often associated with the other two. The number of seeds per head varied from 26 to 28 for both varieties and nitrogen rates, thus showing little change. This is apparent in the correlation values where comparisons involving number of seeds per head were usually not significant. In contrast, the range of values of number of heads bearing seeds was 34 to 59 over varieties but only 48 to 51 over nitrogen rates. The range of weights of 200 seeds was 458 to 674 cg. for varieties but only 560 to 595 cg. over

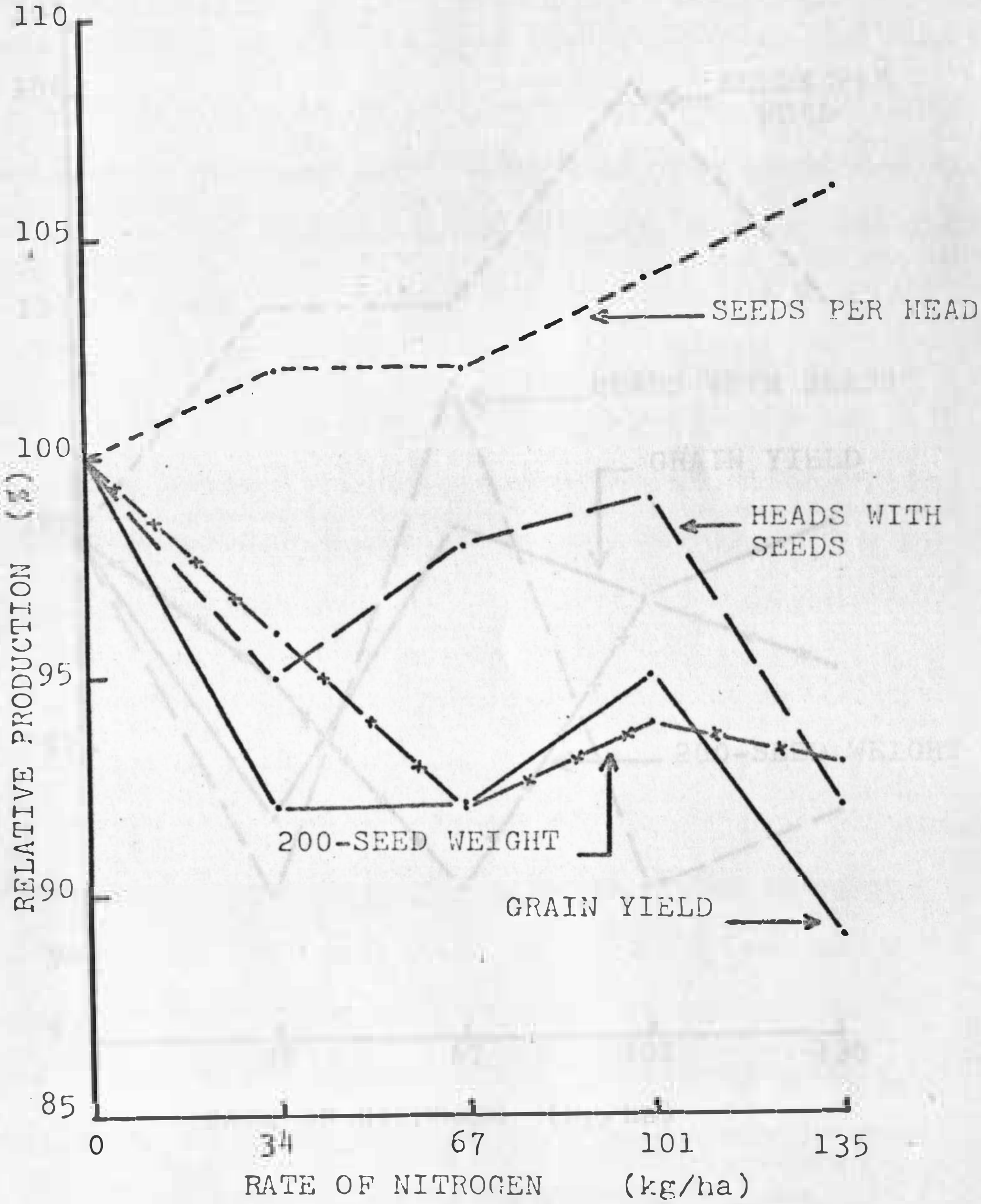


Figure 1. Mean relative yields and yield components as affected by rates of nitrogen of two tall varieties at Brookings under natural rainfall.

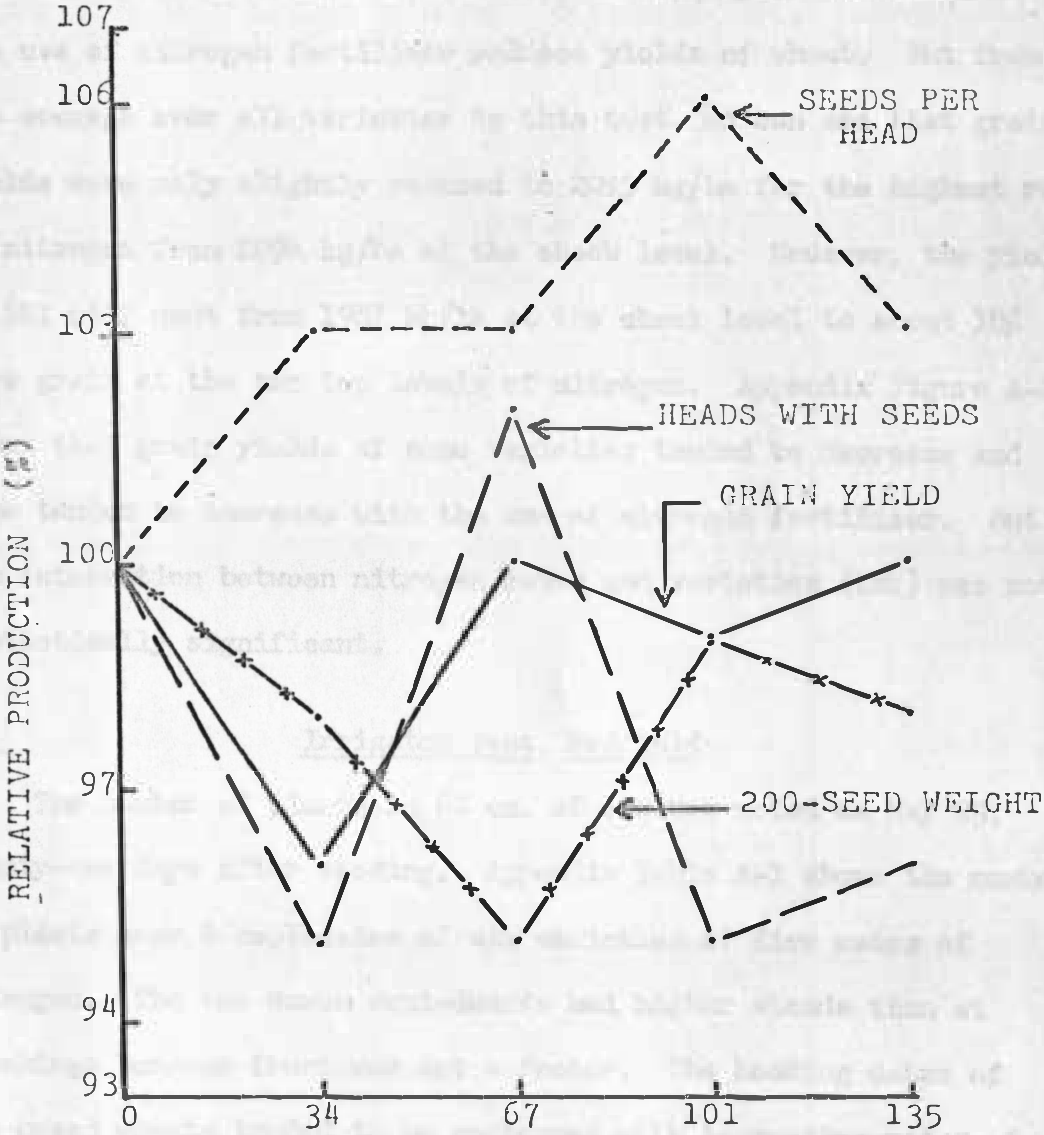


Figure 2. Mean relative yields and yield components as affected by rates of nitrogen of four semi-dwarf varieties at Brookings under natural rainfall.

nitrogen rates.

Some farmers around here believe that under drouth conditions the use of nitrogen fertilizer reduces yields of wheat. But from the average over all varieties in this test, we can see that grain yields were only slightly reduced to 2013 kg/ha for the highest rate of nitrogen from 2094 kg/ha at the check level. However, the yield of SDI 6617 went from 1981 kg/ha at the check level to about 18% more grain at the two top levels of nitrogen. Appendix Figure A-2 shows that grain yields of some varieties tended to decrease and some tended to increase with the use of nitrogen fertilizer. But the interaction between nitrogen rates and varieties (NxV) was not statistically significant.

## Irrigated Test, Redfield

The number of plants in 60 cm. of row was noted on May 29, twenty-one days after seeding. Appendix Table A-1 shows the number of plants over 4 replicates of six varieties at five rates of nitrogen. The two durum semi-dwarfs had higher stands than at Brookings because frost was not a factor. The heading dates of the bread wheats tended to be unchanged with increasing rates of nitrogen but of the durum wheats tended to be a little later. Table 9 evaluates mean squares from analyses of variance.

### Among Bread Wheat Varieties

Tables 10, 11, and 12 show the comparisons between Chris and Penjamo 62, Chris and SDI 6623, and Penjamo 62 and SDI 6623,

Table 9. Significance of mean squares in analyses of variance for the irrigated test, Redfield.

| Sources | df | Yield (kg/ha) straw (60 cm.) | seed (180 cm.) | seed (60 cm.) | Yield components No. heads with seeds (60 cm.) | No. seeds per head | 200-seed wt. (cg) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. in cm. | % lodging | Protein % | yield (kg/ha) | % fertility of florets |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Bread wheat | | | | | | | |
| N rates(N) | 4 | ** | ** | * | * | NS | NS | NS | * | ** | ** | ** | ** | NS |
| Varieties(V) | 2 | NS | ** | * | NS | ** | ** | NS | NS | ** | ** | ** | NS | * |
| NxV | 8 | NS | NS | NS | NS | NS | NS | NS | NS | NS | ** | ** | NS | NS |
| | | | | | | | Durum wheat | | | | | | | |
| N rates(N) | 4 | ** | ** | ** | ** | * | NS | NS | ** | ** | ** | ** | ** | NS |
| Varieties(V) | 2 | * | NS | NS | NS | NS | ** | NS | NS | ** | ** | NS | NS | NS |
| NxV | 8 | NS | NS | NS | NS | NS | NS | NS | NS | NS | ** | NS | NS | NS |

* - significant at 5% level
** - significant at 1% level
NS - not significant

Table 10. Chris and Penjamo 62 compared in the irrigated test, Redfield.

| N rates kg/ha | Varieties | Yield (kg/ha) straw (60 cm.) | seed (180 cm.) | seed (60 cm.) | Components No. heads with seeds (60 cm.) | No. seeds per head | 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | Protein % | yield (kg/ha) | % fertility of florets | Harvest index % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check | Chris | 4139 | 2654 | 2391 | 47 | 29 | 633 | 21 | 50 | 100 | 0.25 | 11.70 | 284 | 98 | 37 |
| | Penjamo 62 | 4726 | 3496 | 3907 | 56 | 32 | 808 | 27 | 60 | 76 | 0 | 10.43 | 409 | 97 | 45 |
| 34(30)* | Chris | 6366 | 3346 | 3866 | 80 | 29 | 625 | 31 | 83 | 104 | 0.25 | 12.15 | 469 | 98 | 38 |
| | Penjamo 62 | 5095 | 3993 | 4030 | 57 | 33 | 793 | 25 | 62 | 83 | 0 | 10.03 | 404 | 97 | 44 |
| 67(60) | Chris | 6994 | 3624 | 3757 | 73 | 29 | 645 | 26 | 77 | 107 | 4.50 | 12.70 | 481 | 98 | 35 |
| | Penjamo 62 | 5765 | 4826 | 4754 | 63 | 35 | 803 | 22 | 67 | 82 | 0 | 10.85 | 521 | 98 | 45 |
| 101(90) | Chris | 7554 | 3596 | 3661 | 79 | 27 | 638 | 28 | 82 | 112 | 2.25 | 12.85 | 470 | 98 | 33 |
| | Penjamo 62 | 6666 | 4744 | 5095 | 70 | 36 | 768 | 22 | 72 | 86 | 0 | 11.03 | 560 | 97 | 43 |
| 135(120) | Chris | 8332 | 3792 | 4207 | 79 | 32 | 618 | 25 | 83 | 109 | 13.75 | 13.88 | 584 | 99 | 34 |
| | Penjamo 62 | 6475 | 4662 | 5109 | 68 | 36 | 770 | 28 | 70 | 83 | 0 | 11.45 | 587 | 96 | 44 |
| Mean | Chris | 6677 | 3402 | 3576 | 72 | 29 | 632 | 26 | 75 | 106 | 4.2 | 12.66 | 457 | 98 | 35 |
| | Penjamo 62 | 5745 | 4344 | 4579 | 63 | 34 | 783 | 25 | 66 | 82 | 0 | 10.76 | 496 | 97 | 44 |
| LSD.05 | (varieties)= | NS | 425 | 505 | NS | 2 | 15 | NS | NS | 1.34 | 0.21 | 0.025 | NS | 0.34 | - |
| C.V. | (%) | =17.61 | 16.70 | 19.03 | 15.65 | 9.17 | 3.22 | 22.19 | 15.70 | 2.35 | 66 | 1.15 | 19.91 | 28.72 | - |

* lbs. per acre
NS - 'not significant'

Table 11. Chris and SDI 6623 compared in the irrigated test, Redfield.

| N rates kg/ha | Varieties | Yield (kg/ha) straw (60 cm.) | seed (180 cm.) | seed (60 cm.) | Components No. heads with seeds (60 cm.) | No. seeds per head | 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | Protein % | yield (kg/ha) | % fertility of florets | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check | Chris | 4139 | 2654 | 2391 | 47 | 29 | 633 | 21 | 50 | 100 | 0.25 | 11.70 | 284 | 98 | 37 |
| | SDI 6623 | 4084 | 2941 | 3278 | 63 | 27 | 723 | 31 | 68 | 66 | 0 | 11.05 | 362 | 97 | 45 |
| 34(30)* | Chris | 6366 | 3346 | 3866 | 80 | 29 | 625 | 31 | 83 | 104 | 0.25 | 12.15 | 469 | 98 | 38 |
| | SDI 6623 | 5450 | 3856 | 4084 | 72 | 29 | 718 | 26 | 77 | 72 | 0 | 10.65 | 437 | 96 | 43 |
| 67(60) | Chris | 6994 | 3624 | 3757 | 73 | 29 | 645 | 26 | 77 | 107 | 4.50 | 12.70 | 481 | 98 | 35 |
| | SDI 6623 | 5819 | 4393 | 4221 | 77 | 28 | 743 | 30 | 83 | 76 | 0 | 11.85 | 502 | 92 | 42 |
| 101(90) | Chris | 7554 | 3596 | 3661 | 79 | 27 | 638 | 28 | 82 | 112 | 2.25 | 12.85 | 470 | 98 | 33 |
| | SDI 6623 | 5464 | 3961 | 3866 | 71 | 28 | 708 | 28 | 76 | 78 | 0 | 11.45 | 441 | 94 | 41 |
| 135(120) | Chris | 8332 | 3792 | 4207 | 79 | 32 | 618 | 25 | 83 | 109 | 13.75 | 13.88 | 584 | 99 | 34 |
| | SDI 6623 | 6939 | 4393 | 4658 | 83 | 29 | 715 | 27 | 86 | 79 | 0 | 12.25 | 568 | 95 | 40 |
| Mean | Chris | 6677 | 3402 | 3576 | 72 | 29 | 632 | 26 | 75 | 106 | 4.2 | 12.66 | 457 | 98 | 35 |
| | SDI 6623 | 5551 | 3908 | 4021 | 73 | 28 | 721 | 28 | 78 | 74 | 0 | 11.45 | 462 | 95 | 42 |
| LSD.05 | (varieties)= | NS | 425 | 505 | NS | 2 | 15 | NS | NS | 1.34 | 0.21 | 0.025 | NS | 0.34 | - |
| C.V. | (%) | =17.61 | 16.70 | 19.03 | 15.65 | 9.17 | 3.22 | 22.19 | 15.70 | 2.35 | 66 | 1.15 | 19.91 | 28.72 | - |

* lbs. per acre
NS - 'not significant'

Table 12. Penjamo 62 and SDI 6623 compared in the irrigated test, Redfield.

| N rates kg/ha | Varieties | Yield (kg/ha) straw (60 cm.) | seed (180 cm.) | seed (60 cm.) | Components No. heads with seeds (60 cm.) | No. seeds per head | 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | Protein % | yield (kg/ha) | % fertility of florets | Harvest index % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check | Penjamo 62 | 4726 | 3496 | 3907 | 56 | 32 | 808 | 27 | 60 | 76 | 0 | 10.43 | 409 | 97 | 45 |
| | SDI 6623 | 4084 | 2941 | 3278 | 63 | 27 | 723 | 31 | 68 | 66 | 0 | 11.05 | 362 | 97 | 45 |
| 34(30)* | Penjamo 62 | 5095 | 3993 | 4030 | 57 | 33 | 793 | 25 | 62 | 83 | 0 | 10.03 | 404 | 97 | 44 |
| | SDI 6623 | 5450 | 3856 | 4084 | 72 | 29 | 718 | 26 | 77 | 72 | 0 | 10.65 | 437 | 96 | 43 |
| 67(60) | Penjamo 62 | 5765 | 4826 | 4754 | 63 | 35 | 803 | 22 | 67 | 82 | 0 | 10.85 | 521 | 98 | 45 |
| | SDI 6623 | 5819 | 4393 | 4221 | 77 | 28 | 743 | 30 | 83 | 76 | 0 | 11.85 | 502 | 92 | 42 |
| 101(90) | Penjamo 62 | 6666 | 4744 | 5095 | 70 | 36 | 768 | 22 | 72 | 86 | 0 | 11.03 | 560 | 97 | 43 |
| | SDI 6623 | 5464 | 3961 | 3866 | 71 | 28 | 708 | 28 | 76 | 78 | 0 | 11.45 | 441 | 94 | 41 |
| 135(120) | Penjamo 62 | 6475 | 4662 | 5109 | 68 | 36 | 770 | 28 | 70 | 83 | 0 | 11.45 | 587 | 96 | 44 |
| | SDI 6623 | 6939 | 4393 | 4658 | 83 | 29 | 715 | 27 | 86 | 79 | 0 | 12.25 | 568 | 95 | 40 |
| Mean | Penjamo 62 | 5745 | 4344 | 4579 | 63 | 34 | 788 | 25 | 66 | 82 | 0 | 10.76 | 496 | 97 | 44 |
| | SDI 6623 | 5551 | 3908 | 4021 | 73 | 28 | 721 | 28 | 78 | 74 | 0 | 11.45 | 462 | 95 | 42 |

* lbs. per acre

respectively. Changes in nitrogen rates significantly affected all characteristics studied except number of seeds per head, 200-seed weight, number of plants, and per cent fertility of main florets (Table 9).

Yields of straw increased from the check to the highest rate of nitrogen by 101% for Chris, 37% for Penjamo 62, and 70% for SDI 6623 (Appendix Table A-11 and Figure A-18). Chris doubled its straw yield because of a 66% increase in tillering but only a 9% increase in height. Correspondingly, Penjamo 62 had 16% more tillers and 11% more height and SDI 6623 had 20% more tillers and 20% more height. The mean square among nitrogen rates for height was highly significant. Varieties differed significantly in height in response to increased rates of nitrogen (Appendix Table A-9 and Figure A-17). There were no significant interactions between nitrogen rates and varieties (NxV) for height or tillering. Tillering significantly increased with rates of nitrogen. Tillers per plant averaged slightly over two for the semi-dwarfs and Chris at the check level. With the addition of nitrogen, ½ tiller per plant, on the average over rates of nitrogen, was added to all three entries. So higher production of straw with increases in available nitrogen was the result both of taller plants and more tillers. Proportionately, the two semi-dwarfs responded a little more in height than Chris but much less in tillering than Chris.

Grain yields of the three bread wheat varieties increased with increased rates of nitrogen (Appendix Table A-3 and Figure A-12).

This was mainly due to more heads bearing seeds rather than to number of seeds per head or 200-seed weight. Grain yields were increased from 2391 kg/ha for the check treatment to 4207 kg/ha for the highest nitrogen rate for Chris, from 3907 kg/ha to 5109 kg/ha for Penjamo 62 (Table 10), and from 3258 kg/ha to 4658 kg/ha for SDI 6623 (Table 11). For Chris the highest number of heads bearing seeds (80) was obtained at the 34 kg/ha rate, 33 heads over the check level. The higher rates were not superior to the 34 kg/ha rate for Chris. For Penjamo 62, the highest number of heads bearing seeds (70) was at the 101 kg/ha rate, 14 heads more than the check level. At the 135 kg/ha rate, SDI 6623 had 83 heads, 20 heads more than the check level. Although the entries seemed to respond differently to nitrogen rates in production of heads, the NxV interaction was not significant.

Lodging mean squares were highly significant for nitrogen rates, varieties, and the interaction of nitrogen rates x varieties. The highest lodging, 14%, was obtained at the highest rate of nitrogen for Chris, but there was no lodging of Penjamo 62 and SDI 6623. The interaction of nitrogen rates x varieties was significant because Chris responded to more nitrogen by lodging whereas the two semi-dwarfs did not. Yet there was no severe lodging even at the highest rate of nitrogen.

Differences in percentages of protein for nitrogen rates, varieties, and the NxV interaction were highly significant (Table 9). Protein levels rose across nitrogen rates from 11.06%

for the check to 12.53% at the highest rate of nitrogen (Appendix Table A-13). Chris averaged about 2% more protein than Penjamo 62 (Table 10) and 1.21% more than SDI 6623 (Table 11). The varieties responded differently to nitrogen rates, accounting for the significant interaction of NxV. Chris rose 2.18% in protein across nitrogen rates while Penjamo 62 and SDI 6623 rose only 1.02% and 1.20%, respectively. Correspondingly, protein yields were increased from 284 to 584 kg/ha, from 409 to 587 kg/ha, and from 362 to 568 kg/ha for Chris, Penjamo 62, and SDI 6623, respectively. Both the highest protein percentages and protein yields were obtained at the highest rate of nitrogen.

Harvest indexes of the three bread wheat varieties tended to decrease with increases in nitrogen. (Appendix Table A-12). Chris averaged 35%, Penjamo 62 averaged 44%, and SDI 6623 averaged 42%. So Chris was 7 to 9% lower in harvest index than the two semi-dwarfs.

Among Durum Wheat Varieties

Tables 13, 14, and 15 show comparisons between Leeds and SDI 669, Leeds and SDI 6617, and SDI 669 and SDI 6617, respectively. Changes in nitrogen rates significantly affected the characteristics studied except 200-seed weight, number of plants, and per cent fertility of main florets (Table 9).

Yields of straw were increased from 4658 to 8169 kg/ha for Leeds, from 4399 to 6871 kg/ha for SDI 669 (Table 13), and from

Table 13. Leeds and SDI 669 compared in the irrigated test, Redfield.

| | | Yield (kg/ha) | | | Components | | | | | | | Protein | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N rates kg/ha | Varieties | straw (60 cm.) | seed (180 cm.) | seed (60 cm.) | No. heads with seeds (60 cm.) | No. seeds per head | 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | % | yield (kg/ha) | % fertility of florets | Harvest index (%) |
| Check | Leeds | 4658 | 2813 | 3060 | 42 | 31 | 855 | 25 | 45 | 94 | 0 | 11.43 | 354 | 98 | 40 |
| | SDI 669 | 4399 | 2891 | 3360 | 40 | 34 | 883 | 21 | 44 | 68 | 0 | 11.15 | 380 | 95 | 43 |
| 34(30)* | Leeds | 5382 | 3319 | 3128 | 43 | 31 | 845 | 23 | 46 | 103 | 0 | 10.98 | 347 | 95 | 37 |
| | SDI 669 | 4767 | 3478 | 3524 | 45 | 33 | 883 | 19 | 48 | 71 | 0 | 11.15 | 399 | 98 | 43 |
| 67(60) | Leeds | 7950 | 4343 | 4617 | 62 | 33 | 838 | 23 | 65 | 110 | 3.75 | 11.85 | 552 | 93 | 37 |
| | SDI 669 | 6133 | 3701 | 3989 | 49 | 36 | 823 | 18 | 55 | 73 | 0 | 12.08 | 477 | 95 | 39 |
| 101(90) | Leeds | 8169 | 4339 | 4590 | 64 | 32 | 825 | 25 | 67 | 111 | 7.00 | 11.80 | 554 | 92 | 36 |
| | SDI 669 | 5355 | 3970 | 3797 | 49 | 35 | 833 | 21 | 54 | 75 | 0 | 12.15 | 462 | 94 | 41 |
| 135(120) | Leeds | 8155 | 3933 | 4317 | 59 | 32 | 833 | 22 | 64 | 111 | 18.75 | 12.68 | 548 | 94 | 35 |
| | SDI 669 | 6871 | 3861 | 4576 | 56 | 35 | 853 | 19 | 63 | 77 | 0 | 12.78 | 586 | 96 | 40 |
| Mean | Leeds | 6862 | 3749 | 3942 | 54 | 32 | 839 | 24 | 57 | 106 | 5.9 | 11.75 | 471 | 94 | 37 |
| | SDI 669 | 5505 | 3580 | 3849 | 48 | 35 | 855 | 20 | 53 | 73 | 0 | 11.86 | 461 | 96 | 41 |
| LSD.05 | (varieties)= | 805 | NS | NS | NS | NS | 28 | NS | NS | 2.6 | 0.35 | NS | NS | NS | - |
| C.V. | (%) | =20.20 | 18.67 | 21.37 | 22.73 | 7.88 | 5.28 | 22.18 | 20.61 | 4.81 | 99.07 | 1.57 | 23.96 | 31.94 | - |

* lbs. per acre

NS - 'not significant'

Table 14. Leeds and SDI 6617 compared in the irrigated test, Redfield.

| N rates kg/ha | Varieties | Yield (kg/ha) straw (60 cm.) | Yield (kg/ha) seed (180 cm.) | Yield (kg/ha) seed (60 cm.) | Components No. heads with seeds (60 cm.) | Components No. seeds per head | Components 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodging | Protein % | Protein yield (kg/ha) | % fertility of florets | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Check | Leeds | 4658 | 2813 | 3060 | 42 | 31 | 855 | 25 | 45 | 94 | 0 | 11.43 | 354 | 98 | 40 |
| | SDI 6617 | 3661 | 2568 | 2527 | 35 | 33 | 800 | 21 | 41 | 62 | 0 | 11.48 | 291 | 95 | 41 |
| 34(30)* | Leeds | 5382 | 3319 | 3128 | 43 | 31 | 845 | 23 | 46 | 103 | 0 | 10.98 | 347 | 95 | 37 |
| | SDI 6617 | 4945 | 2864 | 3470 | 49 | 32 | 803 | 24 | 53 | 65 | 0 | 11.03 | 385 | 96 | 41 |
| 67(60) | Leeds | 7950 | 4343 | 4617 | 62 | 33 | 838 | 23 | 65 | 110 | 3.75 | 11.85 | 552 | 93 | 37 |
| | SDI 6617 | 6639 | 3792 | 4317 | 63 | 32 | 770 | 24 | 68 | 67 | 0 | 11.95 | 519 | 95 | 39 |
| 101(90) | Leeds | 8169 | 4339 | 4590 | 64 | 32 | 825 | 25 | 67 | 111 | 7.00 | 11.80 | 554 | 92 | 36 |
| | SDI 6617 | 6325 | 4147 | 4358 | 64 | 34 | 753 | 26 | 69 | 69 | 0 | 12.28 | 543 | 97 | 41 |
| 135(120) | Leeds | 8155 | 3933 | 4317 | 59 | 32 | 833 | 22 | 64 | 111 | 18.75 | 12.68 | 548 | 94 | 35 |
| | SDI 6617 | 7950 | 4785 | 5450 | 68 | 40 | 735 | 21 | 74 | 75 | 0 | 12.80 | 698 | 94 | 41 |
| Mean | Leeds | 6862 | 3749 | 3942 | 54 | 32 | 839 | 24 | 57 | 106 | 5.9 | 11.75 | 471 | 94 | 37 |
| | SDI 6617 | 5904 | 3631 | 4024 | 56 | 34 | 772 | 23 | 61 | 68 | 0 | 11.91 | 487 | 95 | 41 |
| LSD.05 | (varieties)= | 805 | NS | NS | NS | NS | 28 | NS | NS | 2.6 | 0.35 | NS | NS | NS | - |
| C.V. | (%) | =20.20 | 18.67 | 21.37 | 22.73 | 7.88 | 5.28 | 22.18 | 20.61 | 4.81 | 99.07 | 1.57 | 23.96 | 31.94 | - |

* lbs. per acre
NS - 'not significant'

Table 15. SDI 669 and SDI 6617 compared in the irrigated test, Redfield.

| | | Yield (kg/ha) | | | Components | | | | | | | | Protein | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N rates kg/ha | Varieties | straw (60 cm.) | seed (180 cm.) | seed (60 cm.) | No. heads with seeds (60 cm.) | No. seeds per head | 200-seed wt. (cg.) | No. plants (60 cm.) | No. tillers (60 cm.) | Hgt. (cm.) | % lodg-ing | % | yield (kg/ha) | % fertil-ity of florets | Harv-est index (%) |
| Check | SDI 669 | 4399 | 2891 | 3360 | 40 | 34 | 883 | 21 | 44 | 68 | 0 | 11.15 | 380 | 95 | 43 |
| | SDI 6617 | 3661 | 2568 | 2527 | 35 | 33 | 800 | 21 | 41 | 62 | 0 | 11.48 | 291 | 95 | 41 |
| 34(30)* | SDI 669 | 4765 | 3478 | 3524 | 45 | 33 | 883 | 19 | 48 | 71 | 0 | 11.15 | 399 | 98 | 43 |
| | SDI 6617 | 4945 | 2860 | 3470 | 49 | 32 | 803 | 24 | 53 | 65 | 0 | 11.03 | 385 | 96 | 41 |
| 67(60) | SDI 669 | 6133 | 3701 | 3989 | 49 | 36 | 823 | 18 | 55 | 75 | 0 | 12.08 | 477 | 95 | 39 |
| | SDI 6617 | 6639 | 3792 | 4317 | 63 | 32 | 770 | 24 | 68 | 67 | 0 | 11.95 | 519 | 95 | 39 |
| 101(90) | SDI 669 | 5355 | 3970 | 3797 | 49 | 35 | 833 | 21 | 54 | 75 | 0 | 12.15 | 462 | 94 | 41 |
| | SDI 6617 | 6325 | 4147 | 4358 | 64 | 34 | 753 | 26 | 69 | 69 | 0 | 12.28 | 543 | 97 | 41 |
| 135(120) | SDI 669 | 6871 | 3861 | 4576 | 56 | 35 | 853 | 19 | 63 | 77 | 0 | 12.78 | 586 | 96 | 40 |
| | SDI 6617 | 7950 | 4785 | 5450 | 68 | 40 | 735 | 21 | 74 | 75 | 0 | 12.80 | 698 | 94 | 41 |
| Mean | SDI 669 | 5505 | 3580 | 3849 | 48 | 35 | 855 | 20 | 53 | 73 | 0 | 11.86 | 461 | 96 | 41 |
| | SDI 6617 | 5904 | 3631 | 4024 | 56 | 34 | 772 | 23 | 61 | 68 | 0 | 11.91 | 487 | 95 | 41 |

* lbs. per acre

3661 to 7950 kg/ha for SDI 6617 (Table 14). The highest straw yields were obtained at the highest nitrogen rate for the semi-dwarfs, but for Leeds was obtained at the 101 kg/ha rate. From the check level to the highest rate of nitrogen, numbers of tillers were increased by 19, 19, and 33 tillers for Leeds, SDI 669, and SDI 6617, respectively. Plant heights were increased from 94 to 111 cm. for Leeds, from 68 to 77 cm. for SDI 669, and from 62 to 75 cm. for SDI 6617. The semi-dwarfs were tallest at the highest rate of nitrogen. Leeds was tallest at the middle rate of nitrogen.

Greater straw yields from increased rates of nitrogen were more the result of increases in tillering than from increases in height as is evident below:

| | % increases from check to the 135 kg/ha rate | | |
|---|---|---|---|
| | Tillers | Height | Straw yield |
| Leeds | 42 | 18 | 75 |
| SDI 669 | 43 | 13 | 56 |
| SDI 6617 | 80 | 21 | 117 |

SDI 6617 showed double the per cent increase in number of tillers of the other durums and somewhat greater height which explains its proportionately greater increase (117%) in straw yield.

Grain yields were significantly affected by increased nitrogen rates but not by varieties. There was no significant interaction of nitrogen rates with varieties (Table 9). Appendix Figure A-12 shows mean grain yields in 60 cm. of row for varieties in relation to rates of nitrogen. Yields of grain were increased from 3060 to 4617 kg/ha for Leeds, from 3360 to 4576 kg/ha for SDI 669 (Table 13), and from 2527 to 5450 kg/ha for

SDI 6617 (Table 14). The highest grain yield was obtained at the middle rate of nitrogen for Leeds but at the highest rate of nitrogen for SDI 669 and SDI 6617. Increases in nitrogen caused significantly greater numbers of heads bearing seeds and numbers of seeds per head but not increases in weight of 200 seeds. The numbers of heads bearing seeds were significantly greater at the three higher rates of nitrogen than at the check level (Appendix Table A-6). Increases in number of heads bearing seeds from the check level to the highest rate of nitrogen were 17, 16, and 33% for Leeds, SDI 669, and SDI 6617, respectively. SDI 6617 had only 35 heads bearing seeds at the check rate, 5 heads less than SDI 669 and 7 heads less than Leeds. However, at the highest rate of nitrogen it had 12 heads more than SDI 669 and 9 heads more than Leeds. The numbers of seeds per head were similar for varieties at the four lower rates. At the highest rate of nitrogen, SDI 6617 had 5 seeds per head more than SDI 669 and 8 seeds more than Leeds. Thus, increases in grain yields from the addition of nitrogen were the result of increases in number of heads bearing seeds and number of seeds per head but not in weight of 200 seeds.

SDI 6617 yielded 5450 kg/ha (82 bu./acre) at the highest rate of nitrogen while Leeds yielded only 4317 kg/ha (65 bu./acre). At the next lower rate of nitrogen, grain yields of these two entries were similar. The ability of SDI 6617 to produce more grain at the highest rate of nitrogen than Leeds was the result of its ability to produce more seeds per head and more heads bearing seeds.

Varieties did not differ significantly over nitrogen rates in number of heads bearing seeds or number of seeds per head. However, differences in 200-seed weight were highly significant. Seeds of Leeds and SDI 669 were similar in size but seeds of Leeds were significantly larger than those of SDI 6617. There were no statistically significant interactions of NxV for the three components of yield. Differences in lodging were highly significant between rates of nitrogen, varieties, and for the interaction of nitrogen rates x varieties (Table 9). The two semi-dwarfs did not lodge at all but Leeds did lodge up to 19% with increases in nitrogen rates.

Protein percentages and yields differed significantly over nitrogen rates. There were neither significant differences between varieties nor were the interactions of NxV significant (Table 9). Protein percentages and yields are shown in Appendix Table A-13 and A-14 or Figure A-19 and A-20, respectively. The protein percentages at the three highest rates of nitrogen were significantly higher than at either the lowest rate of nitrogen or the check level. Average protein increased 1.4 percentage units from the check level to the highest nitrogen rate.

Harvest indexes tended to decrease with increasing rates of nitrogen (Appendix Table A-12) but not very much. The mature weight of Leeds was 37% grain and of the two semi-dwarfs 41% grain. While the semi-dwarfs were more efficient in the production of grain than Leeds, they did not produce significantly more grain than Leeds over rates of nitrogen.

Correlation values are shown in Table 16. Grain yields showed a highly positive relationship with straw yields in all classes of comparisons. Grain yields were greatly associated with number of heads bearing seeds and number of seeds per head in all classes of comparisons but not with 200-seed weight except for the bread wheats for all heights. Figures 3 and 4 graph the response of yields and its components to changes in rates of nitrogen of two tall and four semi-dwarf varieties. A distinctly positive association is apparent in all height classes between straw yields and numbers of heads bearing seeds (Table 9). Number of seeds per head was associated with straw yield only for the durum wheats and all semi-dwarfs. There were no significant associations between straw yields and 200-seed weights. Number of heads bearing seeds and 200-seed weight were negatively related in all classes except for the combined bread wheats. The relationship between 200-seed weight and number of seeds per head was positive and significant for the bread wheats but not for the combined durum wheats. The number of heads bearing seeds was significantly associated negatively with number of seeds per head only for all semi-dwarfs.

Table 16. Correlation values for individual observations for some of the characteristics measured at the irrigated test, Redfield.

| Class of wheat | Hgt. | df | Grain vs straw | Grain vs 200-seed wt. | Grain vs heads with seeds | Grain vs seeds per head | Straw vs 200-seed wt. | Straw vs heads with seeds | Straw vs seeds per head | 200-seed wt. vs heads with seeds | 200-seed wt. vs seeds per head | Heads with seeds vs seeds per head |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bread | All | 58 | 0.68** | 0.41** | 0.67** | 0.46** | -0.24 | 0.82** | 0.12 | -0.20 | 0.39** | -0.23 |
| Durum | All | 58 | 0.90** | -0.11 | 0.93** | 0.44** | -0.17 | 0.90** | 0.28* | -0.28* | -0.25 | 0.18 |
| Both | Tall | 38 | 0.91** | 0.16 | 0.71** | 0.40** | 0.004 | 0.76** | 0.26 | -0.49** | 0.42** | -0.18 |
| Both | Semi-dwarf | 78 | 0.92** | -0.05 | 0.78** | 0.35** | -0.12 | 0.74** | 0.33** | -0.46** | 0.25* | -0.23* |

* - significant at 5% level
** - significant at 1% level

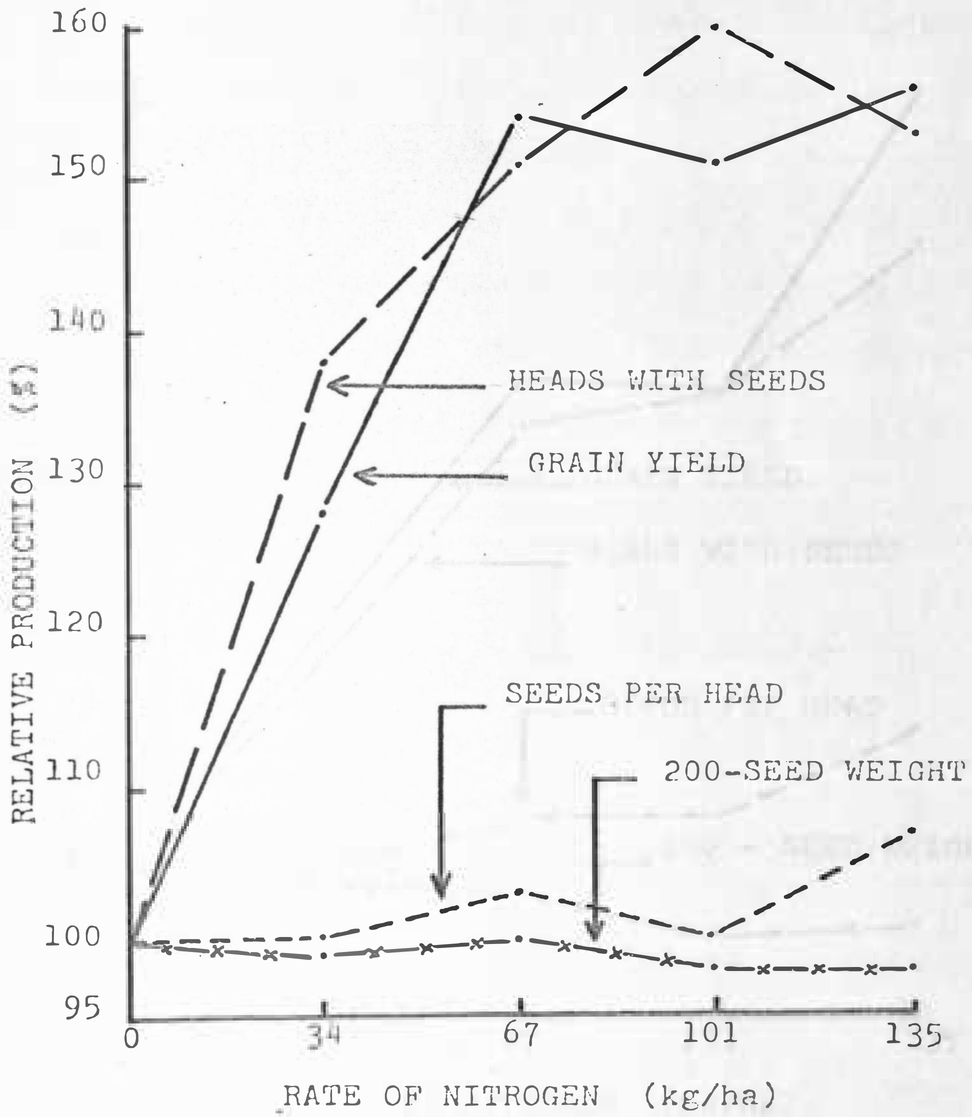


Figure 3. Mean relative yields and yield components as affected by rates of nitrogen of two tall varieties at Redfield under irrigation.

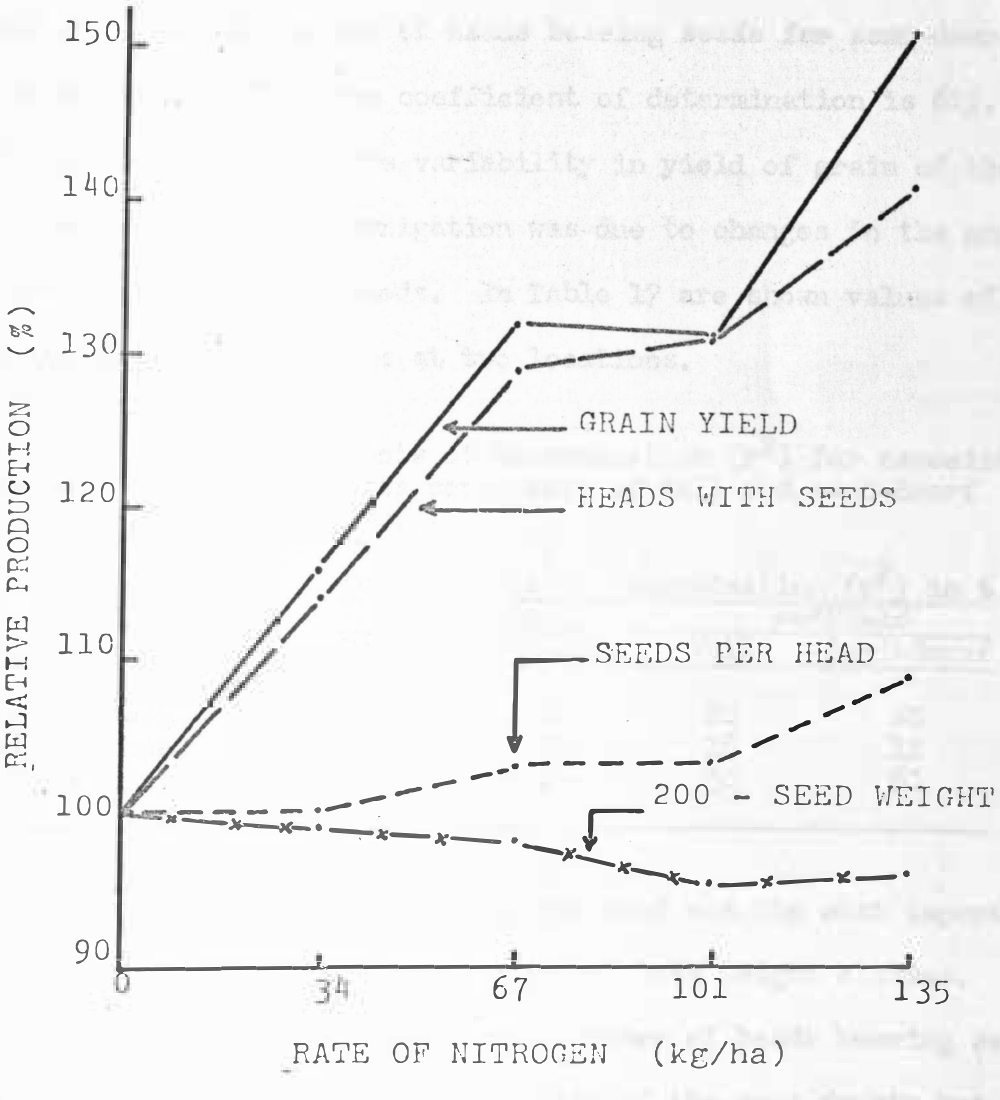


Figure 4. Mean relative yields and yield components as affected by rates of nitrogen of four semi-dwarf varieties at Redfield under irrigation.

## Coefficients of Determination ($r^2$)

Of greater usefulness than correlation is the coefficient of determination ($r^2$). For instance, the correlation value between yield of grain and number of heads bearing seeds for semi-dwarfs at Redfield is 0.78. The coefficient of determination is 61%. This means that 61% of the variability in yield of grain of the four semi-dwarfs under irrigation was due to changes in the number of heads that produced seeds. In Table 17 are shown values of $r^2$ for the two height classes at two locations.

Table 17. Coefficients of determination ($r^2$) for associations between grain yield and its components of tall and semi-dwarf varieties at two locations.

| Grain yield in association with | Coefficients of determination ($r^2$) in % | | | |
|---|---|---|---|---|
| | Brookings | | Redfield | |
| | Tall | Semi-dwarf | Tall | Semi-dwarf |
| 200-seed weight | 14 | 12 | NS | NS |
| Seeds per head | 29 | 20 | 16 | 12 |
| Heads bearing seeds | NS | 14 | 50 | 61 |

At Brookings, number of seeds per head was the most important factor in determining yields of grain of both height classes. 200-seed weight was next in importance. Number of heads bearing seeds contributed importantly to grain yields of the semi-dwarfs but not for the tall varieties.

At Redfield, the most important factor affecting yields of grain of tall and semi-dwarf varieties was the number of heads bearing seeds. Number of seeds per head was the second in importance while 200-seed weight was not associated with grain yield.

## SUMMARY AND CONCLUSIONS

One tall and two semi-dwarf bread wheats and one tall and two semi-dwarf durum wheats were tested under natural rainfall and irrigated conditions at five levels of nitrogen and constant high levels of phosphorus fertilization.

In the dryland test at Brookings, increases in nitrogen rates did not significantly affect grain yield, yield components, or other characteristics of both bread and durum wheats except number of plants of bread wheats. The differences in stand noted after frost did not appear to bear a relationship to nitrogen rates. Large differences in straw yield between varieties were explained on the basis of plant height and tillering for bread wheats but only plant height for durum wheats. Grain yields were similar between varieties, but yield components differed significantly. The three components of yield of bread wheats differed significantly, but only two components, number of heads bearing seeds and 200-seed weight, of durum wheats differed significantly. The response to nitrogen fertilization of yield components between varieties led to a balance in grain yield. Protein percentages and protein yields differed significantly between varieties of bread wheat but not for durum wheat. The tall varieties were higher in protein percentages and protein yields than the semi-dwarf varieties for both bread and durum wheats. Harvest indexes for the semi-dwarfs were higher than for the tall varieties.

Correlation values were used to study the associations among characteristics. Number of heads bearing seeds and number of seeds per head had the greatest direct effect upon yield of grain. Weight of 200 seeds had little effect upon yield of grain. Grain and straw yields varied together.

In the irrigated test at Redfield, changes in nitrogen rates increased grain yields significantly of both bread and durum wheats. Only the number of heads bearing seeds differed significantly for bread wheats, but number of heads bearing seeds and number of seeds per head differed significantly for durum wheats. Other significant effects of nitrogen on both bread and durum wheats were increases in straw yield due to more tillers and greater height, and increases in lodging, per cent protein, and yield of protein.

Varieties at Redfield showed large differences in their response to fertilization for the components number of seeds per head and 200-seed weight that led to differences in grain yields for bread wheats. Grain yields were similar among varieties of durum wheats because only 200-seed weights differed significantly. The differences in plant height between varieties did not lead to differences in straw yield for bread wheats but did for durum wheats. Other characteristics among bread wheats that differed significantly were lodging, protein percentage, and per cent fertility of main florets whereas only lodging differed significantly between durum wheats. Harvest indexes decreased slightly with increasing rates of nitrogen. Semi-dwarfs were higher in harvest index than tall varieties.

Relationships between characteristics were studied from simple linear correlation. All three components had a substantial effect upon grain yields of bread wheats, but only two components, number of heads bearing seeds and number of seeds per head, had much relationship to grain yields of both height classes of durum wheats. Grain and straw yields were highly associated.

Grain yields under natural rainfall tended to decrease with increases in rates of nitrogen but rose sharply under irrigation. Number of seeds per head always showed an increasing trend while weight of 200 seeds always showed a decreasing trend with rates of nitrogen at both test sites for both height classes. Thus, they seemed to be compensating in their combined effect upon yield. In contrast, number of heads bearing seeds tended to decline with increases in nitrogen rates on dryland but rose sharply under irrigation.

Over nitrogen rates, plant height under irrigation was 39% greater for Chris and 38% greater for the semi-dwarfs of bread wheats than under natural rainfall. Leeds was 45% taller and the two semi-dwarfs 28% taller under irrigation than under natural rainfall. Lodging was of minor importance in the tall varieties and did not occur in the semi-dwarfs.

From this test we have found that SDI 6617 at rates of nitrogen below 135 kg/ha (120 lbs./acre) under irrigation was not different in grain yield from Leeds, the commercial check. But at the

135 kg/ha rate, SDI 6617 yielded about 23% more grain than Leeds because it had the ability at this high rate of nitrogen to produce more seeds per head and more heads per plant than Leeds and thus to outyield Leeds. Wheat breeders should therefore use a very high rate of nitrogen and phosphorus fertilization on irrigated breeding and testing plots.

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# APPENDIX

Table A-1.
Mean number of plants from 60 cm. per sub-plot over 4 replicates.

Dryland test, Brookings.[1]

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 26 | 25 | 24 | 23 | 28 | 25 |
| Penjamo 62 | 22 | 24 | 25 | 22 | 19 | 22 |
| SDI 6623 | 30 | 31 | 24 | 26 | 32 | 29 |
| Mean | 26 | 27 | 24 | 24 | 26 | |
| Leeds | 23 | 23 | 24 | 29 | 24 | 25 |
| SDI 669 | 19 | 15 | 22 | 14 | 19 | 18 |
| SDI 6617 | 19 | 17 | 21 | 20 | 22 | 20 |
| Mean | 20 | 18 | 22 | 21 | 22 | |

1/Noted on May 13 after frost damage on May 3 and 4.

LSD.05: Bread wheat - varieties 3, N rates 4, C.V. 19.64%
Durum wheat - varieties 3, N rates NS, C. V. 22.14%

Irrigated test, Redfield.[1]

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 21 | 31 | 26 | 28 | 25 | 26 |
| Penjamo 62 | 27 | 25 | 22 | 22 | 28 | 25 |
| SDI 6623 | 31 | 26 | 30 | 28 | 27 | 28 |
| Mean | 26 | 27 | 26 | 26 | 27 | |
| Leeds | 25 | 23 | 23 | 25 | 22 | 24 |
| SDI 669 | 21 | 19 | 18 | 21 | 19 | 20 |
| SDI 6617 | 21 | 24 | 24 | 26 | 21 | 23 |
| Mean | 22 | 22 | 22 | 24 | 21 | |

1/Noted on May 29

LSD.05: Bread wheat - varieties NS, N rates NS, C.V. 22.19%
Durum wheat - varieties NS, N rates NS, C.V. 22.18%

Table A-2.

Mean June heading date over 4 replicates in the dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 16 | 16 | 16 | 16 | 17 | 16 |
| Penjamo 62 | 15 | 15 | 15 | 14 | 15 | 15 |
| SDI 6623 | 14 | 14 | 15 | 15 | 14 | 14 |
| Mean | 15 | 15 | 15 | 15 | 15 | |
| Leeds | 17 | 17 | 17 | 17 | 17 | 17 |
| SDI 669 | 17 | 17 | 17 | 17 | 17 | 17 |
| SDI 6617 | 17 | 18 | 17 | 17 | 17 | 17 |
| Mean | 17 | 17 | 17 | 17 | 17 | |

Mean July heading date over 4 replicates in the irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 1 | 1 | 1 | 3 | 2 | 2 |
| Penjamo 62 | 2 | 2 | 2 | 2 | 1 | 2 |
| SDI 6623 | 2 | 3 | 2 | 2 | 2 | 2 |
| Mean | 2 | 2 | 2 | 2 | 2 | |
| Leeds | 3 | 3 | 4 | 5 | 5 | 4 |
| SDI 669 | 3 | 4 | 4 | 6 | 3 | 4 |
| SDI 6617 | 4 | 5 | 4 | 6 | 5 | 5 |
| Mean | 3 | 4 | 4 | 6 | 4 | |

Table A-3.
Mean grain yield from 60 cm. over 4 replicates (kg/ha).

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 2254 | 2008 | 1899 | 1912 | 1885 | 1992 |
| Penjamo 62 | 2058 | 1953 | 1953 | 1926 | 1858 | 1950 |
| SDI 6623 | 2076 | 1858 | 2035 | 1885 | 1748 | 1920 |
| Mean | 2129 | 1950 | 1962 | 1908 | 1830 | |
| Leeds | 2076 | 1994 | 2090 | 2199 | 1981 | 2068 |
| SDI 669 | 2117 | 1981 | 2172 | 1994 | 2268 | 2106 |
| SDI 6617 | 1981 | 2090 | 2063 | 2350 | 2336 | 2164 |
| Mean | 2058 | 2022 | 2108 | 2181 | 2195 | |

LSD.05: Bread wheat - varieties NS, N rates NS, C.V. 13.23%
Durum wheat - varieties NS, N rates NS, C.V. 14.68%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 2391 | 3866 | 3757 | 3661 | 4207 | 3576 |
| Penjamo 62 | 3907 | 4030 | 4754 | 5095 | 5109 | 4579 |
| SDI 6623 | 3278 | 4084 | 4221 | 3866 | 4658 | 4021 |
| Mean | 3192 | 3993 | 4244 | 4207 | 4658 | |
| Leeds | 3060 | 3128 | 4617 | 4590 | 4317 | 3942 |
| SDI 669 | 3360 | 3524 | 3989 | 3797 | 4576 | 3849 |
| SDI 6617 | 2527 | 3470 | 4317 | 4358 | 5450 | 4024 |
| Mean | 2982 | 3374 | 4308 | 4248 | 4781 | |

LSD.05: Bread wheat - varieties 505 kg/ha, N rates 651 kg/ha, C.V. 19.03%

Durum wheat - varieties NS, N rates 731 kg/ha, C.V. 21.37%

Table A-4.
Mean grain yield from 180 cm. over 4 replicates (kg/ha).

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 2185 | 2276 | 1889 | 2194 | 2121 | 2133 |
| Penjamo 62 | 2034 | 2285 | 2172 | 2090 | 2117 | 2139 |
| SDI 6623 | 2026 | 2090 | 2153 | 2108 | 1817 | 2049 |
| Mean | 2082 | 2217 | 2071 | 2131 | 2036 | |
| Leeds | 2099 | 2035 | 1962 | 2354 | 2049 | 2099 |
| SDI 669 | 2090 | 2263 | 2076 | 2604 | 2276 | 2261 |
| SDI 6617 | 2085 | 2249 | 2058 | 2413 | 2504 | 2261 |
| Mean | 2091 | 2182 | 2032 | 2457 | 2276 | |

LSD.05: Bread wheat - varieties NS, N rates NS, C.V. 10.84%
Durum wheat - varieties NS, N rates NS, C.V. 14.38%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 2654 | 3346 | 3624 | 3596 | 3792 | 3402 |
| Penjamo 62 | 3496 | 3993 | 4826 | 4744 | 4662 | 4344 |
| SDI 6623 | 2941 | 3856 | 4393 | 3961 | 4393 | 3908 |
| Mean | 3030 | 3732 | 4281 | 4100 | 4282 | |
| Leeds | 2813 | 3319 | 4343 | 4339 | 3933 | 3749 |
| SDI 669 | 2891 | 3478 | 3701 | 3970 | 3861 | 3580 |
| SDI 6617 | 2568 | 2864 | 3792 | 4147 | 4785 | 3631 |
| Mean | 2757 | 3220 | 3945 | 4152 | 4192 | |

LSD.05: Bread wheat - varieties 425 kg/ha, N rates 547 kg/ha,
C.V. 16.70%

Durum wheat - varieties NS, N rates 575 kg/ha,
C.V. 18.67%

Table A-5.
Mean number of tillers from 60 cm. per sub-plot over 4 replicates.

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 69 | 61 | 66 | 64 | 66 | 65 |
| Penjamo 62 | 55 | 55 | 52 | 52 | 46 | 52 |
| SDI 6623 | 60 | 60 | 61 | 54 | 58 | 59 |
| Mean | 61 | 59 | 60 | 57 | 57 | |
| Leeds | 51 | 51 | 54 | 55 | 49 | 52 |
| SDI 669 | 51 | 46 | 57 | 44 | 57 | 51 |
| SDI 6617 | 49 | 47 | 53 | 53 | 59 | 52 |
| Mean | 50 | 48 | 54 | 51 | 55 | |

LSD.05: Bread wheat - varieties 4, N rates NS, C.V. 11.22%
Durum wheat - varieties NS, N rates NS, C.V. 15.65%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 50 | 83 | 77 | 82 | 83 | 75 |
| Penjamo 62 | 60 | 62 | 67 | 72 | 70 | 66 |
| SDI 6623 | 68 | 77 | 83 | 76 | 86 | 78 |
| Mean | 59 | 74 | 76 | 77 | 80 | |
| Leeds | 45 | 46 | 65 | 67 | 64 | 57 |
| SDI 669 | 44 | 48 | 55 | 54 | 63 | 53 |
| SDI 6617 | 41 | 53 | 68 | 69 | 74 | 61 |
| Mean | 43 | 49 | 63 | 63 | 67 | |

LSD.05: Bread wheat - varieties NS, N rates 10, C.V. 15.70%
Durum wheat - varieties NS, N rates 10, C.V. 20.61%

Table A-6.
Mean number of heads bearing seeds from 60 cm. per sub-plot over 4 replicates.

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 62 | 57 | 59 | 59 | 57 | 59 |
| Penjamo 62 | 52 | 50 | 48 | 48 | 44 | 48 |
| SDI 6623 | 57 | 56 | 58 | 52 | 51 | 55 |
| Mean | 57 | 54 | 55 | 53 | 51 | |
| Leeds | 45 | 45 | 46 | 47 | 41 | 45 |
| SDI 669 | 44 | 39 | 48 | 37 | 45 | 43 |
| SDI 6617 | 42 | 41 | 44 | 48 | 47 | 44 |
| Mean | 44 | 42 | 46 | 44 | 44 | |

LSD.05: Bread wheat - varieties 4, N rates NS, C.V. 12.26%
Durum wheat - varieties 4, N rates NS, C.V. 14.00%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 47 | 80 | 73 | 79 | 79 | 72 |
| Penjamo 62 | 56 | 57 | 63 | 70 | 68 | 63 |
| SDI 6623 | 63 | 72 | 77 | 71 | 83 | 73 |
| Mean | 55 | 70 | 71 | 73 | 77 | |
| Leeds | 42 | 43 | 62 | 64 | 59 | 54 |
| SDI 669 | 40 | 45 | 49 | 49 | 56 | 48 |
| SDI 6617 | 35 | 49 | 63 | 64 | 68 | 56 |
| Mean | 39 | 46 | 58 | 59 | 61 | |

LSD.05: Bread wheat - varieties NS, N rates 9, C.V. 15.65%
Durum wheat - varieties NS, N rates 10, C.V. 22.73%

Table A-7.
Mean number of seeds per head over 4 replicates.

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 25 | 26 | 25 | 26 | 26 | 26 |
| Penjamo 62 | 26 | 26 | 27 | 28 | 29 | 27 |
| SDI 6623 | 29 | 28 | 30 | 28 | 26 | 28 |
| Mean | 27 | 27 | 27 | 27 | 27 | |
| Leeds | 25 | 25 | 26 | 26 | 27 | 26 |
| SDI 669 | 26 | 28 | 26 | 30 | 28 | 28 |
| SDI 6617 | 27 | 29 | 28 | 28 | 28 | 28 |
| Mean | 26 | 27 | 27 | 28 | 28 | |

LSD.05: Bread wheat - varieties 2, N rates NS, C.V. 10.19%
Durum wheat - varieties NS, N rates NS, C.V. 11.15%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 29 | 29 | 29 | 27 | 32 | 29 |
| Penjamo 62 | 32 | 33 | 35 | 36 | 36 | 34 |
| SDI 6623 | 27 | 29 | 28 | 28 | 29 | 28 |
| Mean | 29 | 30 | 31 | 30 | 32 | |
| Leeds | 31 | 31 | 33 | 32 | 32 | 32 |
| SDI 669 | 34 | 33 | 36 | 35 | 35 | 35 |
| SDI 6617 | 33 | 32 | 32 | 34 | 40 | 34 |
| Mean | 33 | 32 | 34 | 34 | 36 | |

LSD.05: Bread wheat - varieties 2, N rates NS, C.V. 9.17%
Durum wheat - varieties NS, N rates 2, C.V. 7.88%

Table A-8.
Mean 200-seed weight (cg.) per sub-plot over 4 replicates.

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 535 | 498 | 468 | 463 | 463 | 485 |
| Penjamo 62 | 573 | 565 | 550 | 543 | 523 | 551 |
| SDI 6623 | 460 | 443 | 433 | 468 | 488 | 458 |
| Mean | 523 | 502 | 484 | 491 | 491 | |
| Leeds | 673 | 663 | 648 | 668 | 663 | 663 |
| SDI 669 | 688 | 680 | 645 | 683 | 675 | 674 |
| SDI 6617 | 643 | 635 | 613 | 638 | 635 | 633 |
| Mean | 668 | 659 | 635 | 663 | 658 | |

LSD.05: Bread wheat - varieties 21 cg., N rates NS, C.V. 6.43%
Durum wheat - varieties 18 cg., N rates NS, C.V. 4.14%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 633 | 625 | 645 | 638 | 618 | 632 |
| Penjamo 62 | 808 | 793 | 803 | 768 | 770 | 788 |
| SDI 6623 | 723 | 718 | 743 | 708 | 715 | 721 |
| Mean | 721 | 712 | 730 | 705 | 701 | |
| Leeds | 855 | 845 | 838 | 825 | 833 | 839 |
| SDI 669 | 883 | 883 | 823 | 833 | 853 | 855 |
| SDI 6617 | 800 | 803 | 770 | 753 | 735 | 772 |
| Mean | 846 | 844 | 810 | 804 | 807 | |

LSD.05: Bread wheat - varieties 15 cg., N rates NS, C.V. 3.22%
Durum wheat - varieties 28 cg., N rates NS, C.V. 5.28%

Table A-9.
Mean plant height (cm.) over 4 replicates.

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 77 | 78 | 74 | 76 | 75 | 76 |
| Penjamo 62 | 62 | 60 | 57 | 58 | 60 | 59 |
| SDI 6623 | 53 | 54 | 55 | 55 | 55 | 54 |
| Mean | 64 | 64 | 62 | 63 | 63 | |
| Leeds | 74 | 74 | 72 | 72 | 72 | 73 |
| SDI 669 | 55 | 57 | 55 | 57 | 56 | 56 |
| SDI 6617 | 52 | 56 | 53 | 54 | 54 | 54 |
| Mean | 60 | 62 | 60 | 61 | 61 | |

LSD.05: Bread wheat - varieties 1.5 cm., N rates NS, C.V. 3.70%
Durum wheat - varieties 1.5 cm., N rates NS, C.V. 3.77%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 100 | 104 | 107 | 112 | 109 | 106 |
| Penjamo 62 | 76 | 83 | 82 | 86 | 83 | 82 |
| SDI 6623 | 66 | 72 | 76 | 78 | 79 | 74 |
| Mean | 81 | 86 | 88 | 92 | 90 | |
| Leeds | 94 | 103 | 110 | 111 | 111 | 106 |
| SDI 669 | 68 | 71 | 75 | 75 | 77 | 73 |
| SDI 6617 | 62 | 65 | 67 | 69 | 75 | 68 |
| Mean | 75 | 80 | 84 | 85 | 88 | |

LSD.05: Bread wheat - varieties 1.3 cm., N rates 1.7, C.V. 2.35%
Durum wheat - varieties 2.6 cm., N rates 3.3, C.V. 4.81%

Table A-10.
Mean lodging percentage per sub-plot over 4 replicates.

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 4.50 | 3.25 | 3.25 | 3.25 | 2.75 | 3.40 |
| Penjamo 62 | 2.50 | 1.75 | 1.75 | 1.75 | 1.75 | 1.90 |
| SDI 6623 | 1.50 | 0.75 | 0.75 | 0.50 | 0 | 0.65 |
| Mean | 2.83 | 1.92 | 1.83 | 1.83 | 1.50 | |
| Leeds | 1.00 | 1.00 | 1.25 | 2.00 | 1.50 | 1.35 |
| SDI 669 | 0.50 | 0.25 | 1.25 | 0.25 | 1.00 | 0.65 |
| SDI 6617 | 0.50 | 0.75 | 1.00 | 2.00 | 0.75 | 1.00 |
| Mean | 0.67 | 0.67 | 1.17 | 1.42 | 1.08 | |

LSD.05: Bread wheat - varieties 0.26, N rates NS, C.V. 31.97%
Durum wheat - varieties 0.30, N rates NS, C.V. 54.76%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 0.25 | 0.25 | 4.50 | 2.25 | 13.75 | 4.2 |
| Penjamo 62 | 0 | 0 | 0 | 0 | 0 | 0 |
| SDI 6623 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 0.08 | 0.08 | 1.50 | 0.75 | 4.58 | |
| Leeds | 0 | 0 | 3.75 | 7.00 | 18.75 | 5.9 |
| SDI 669 | 0 | 0 | 0 | 0 | 0 | 0 |
| SDI 6617 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 0 | 0 | 1.25 | 2.33 | 6.25 | |

LSD.05: Bread wheat - varieties 0.21, N rates 0.27, C.V. 66.00%
Durum wheat - varieties 0.35, N rates 0.45, C.V. 99.07%

Table A-11.
Mean straw yield from 60 cm. over 4 replicates (kg/ha).

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 4317 | 3811 | 3811 | 3934 | 3757 | 3926 |
| Penjamo 62 | 3206 | 2910 | 3033 | 3005 | 2773 | 2985 |
| SDI 6623 | 3155 | 3128 | 3278 | 2992 | 2814 | 3073 |
| Mean | 3559 | 3283 | 3374 | 3310 | 3115 | |
| Leeds | 3716 | 3784 | 4043 | 4194 | 3647 | 3876 |
| SDI 669 | 3716 | 3442 | 3893 | 3606 | 3866 | 3705 |
| SDI 6617 | 3224 | 3265 | 3374 | 3620 | 3688 | 3434 |
| Mean | 3552 | 3497 | 3770 | 3807 | 3734 | |

LSD.05: Bread wheat - varieties 219 kg/ha, N rates NS, C.V. 10.06%
Durum wheat - varieties 297 kg/ha, N rates NS, C.V. 12.35%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 4139 | 6366 | 6994 | 7554 | 8332 | 6677 |
| Penjamo 62 | 4726 | 5095 | 5765 | 6666 | 6475 | 5745 |
| SDI 6623 | 4084 | 5450 | 5819 | 5464 | 6939 | 5551 |
| Mean | 4316 | 5637 | 6193 | 6561 | 7249 | |
| Leeds | 4658 | 5382 | 7950 | 8169 | 8155 | 6862 |
| SDI 669 | 4399 | 4767 | 6133 | 5355 | 6871 | 5505 |
| SDI 6617 | 3661 | 4945 | 6639 | 6325 | 7950 | 5904 |
| Mean | 4239 | 5031 | 6907 | 6616 | 7659 | |

LSD.05: Bread wheat - varieties NS, N rates 890 kg/ha, C.V. 17.61%
Durum wheat - varieties 805 kg/ha, N rates 1037 kg/ha, C.V. 20.20%

Table A-12.

Harvest index in the dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 34 | 35 | 33 | 33 | 33 | 34 |
| Penjamo 62 | 39 | 40 | 39 | 39 | 40 | 39 |
| SDI 6623 | 40 | 37 | 38 | 39 | 38 | 38 |
| Mean | 38 | 37 | 37 | 37 | 37 | |
| Leeds | 36 | 35 | 34 | 34 | 35 | 35 |
| SDI 669 | 36 | 37 | 36 | 36 | 37 | 36 |
| SDI 6617 | 38 | 39 | 38 | 39 | 39 | 39 |
| Mean | 37 | 37 | 36 | 36 | 37 | |

Harvest index in the irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 37 | 38 | 35 | 33 | 34 | 35 |
| Penjamo 62 | 45 | 44 | 45 | 43 | 44 | 44 |
| SDI 6623 | 45 | 43 | 42 | 41 | 40 | 42 |
| Mean | 42 | 42 | 41 | 39 | 39 | |
| Leeds | 40 | 37 | 37 | 36 | 35 | 37 |
| SDI 669 | 43 | 43 | 39 | 41 | 40 | 41 |
| SDI 6617 | 41 | 41 | 39 | 41 | 41 | 41 |
| Mean | 41 | 40 | 38 | 39 | 39 | |

Table A-13.
Mean protein percentage per sub-plot over 4 replicates.

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 15.05 | 15.65 | 16.05 | 16.03 | 15.88 | 15.73 |
| Penjamo 62 | 13.35 | 13.45 | 13.95 | 13.75 | 13.83 | 13.67 |
| SDI 6623 | 14.50 | 14.55 | 14.73 | 14.60 | 14.80 | 14.64 |
| Mean | 14.30 | 14.55 | 14.91 | 14.79 | 14.84 | |
| Leeds | 14.83 | 16.05 | 16.38 | 16.48 | 16.48 | 16.04 |
| SDI 669 | 15.03 | 15.08 | 15.43 | 15.08 | 15.08 | 15.14 |
| SDI 6617 | 14.73 | 14.85 | 15.15 | 14.93 | 15.30 | 14.99 |
| Mean | 14.86 | 15.33 | 15.65 | 15.50 | 15.62 | |

LSD.05: Bread wheat - varieties 0.034, N rates NS, C.V. 1.36%
Durum wheat - varieties NS, N rates NS, C.V. 15.5%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 11.70 | 12.15 | 12.70 | 12.85 | 13.88 | 12.66 |
| Penjamo 62 | 10.43 | 10.03 | 10.85 | 11.03 | 11.45 | 10.76 |
| SDI 6623 | 11.05 | 10.65 | 11.85 | 11.45 | 12.25 | 11.45 |
| Mean | 11.06 | 10.94 | 11.80 | 11.78 | 12.53 | |
| Leeds | 11.43 | 10.98 | 11.85 | 11.80 | 12.68 | 11.75 |
| SDI 669 | 11.15 | 11.15 | 12.08 | 12.15 | 12.78 | 11.86 |
| SDI 6617 | 11.48 | 11.03 | 11.95 | 12.28 | 12.80 | 11.91 |
| Mean | 11.35 | 11.05 | 11.96 | 12.08 | 12.75 | |

LSD.05: Bread wheat - varieties 0.025, N rates 0.032, C.V. 1.15%
Durum wheat - varieties NS, N rates 0.045, C.V. 1.57%

Table A-14.
Mean protein yield over 4 replicates (kg/ha).

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 339 | 314 | 305 | 308 | 299 | 313 |
| Penjamo 62 | 273 | 264 | 270 | 264 | 256 | 265 |
| SDI 6623 | 298 | 270 | 299 | 275 | 260 | 280 |
| Mean | 303 | 283 | 291 | 282 | 272 | |
| Leeds | 306 | 320 | 339 | 362 | 325 | 330 |
| SDI 669 | 319 | 298 | 332 | 299 | 343 | 318 |
| SDI 6617 | 292 | 310 | 313 | 351 | 357 | 325 |
| Mean | 306 | 309 | 328 | 337 | 342 | |

LSD.05: Bread wheat - varieties 22 kg/ha, N rates NS, C.V. 11.83%
Durum wheat - varieties NS, N rates NS, C.V. 45.97%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) Check | 34 | 67 | 101 | 135 | Mean |
|---|---|---|---|---|---|---|
| Chris | 284 | 469 | 481 | 470 | 584 | 457 |
| Penjamo 62 | 409 | 404 | 521 | 560 | 587 | 496 |
| SDI 6623 | 362 | 437 | 502 | 441 | 568 | 462 |
| Mean | 352 | 437 | 501 | 490 | 580 | |
| Leeds | 354 | 347 | 552 | 554 | 548 | 471 |
| SDI 669 | 380 | 399 | 477 | 462 | 586 | 461 |
| SDI 6617 | 291 | 385 | 519 | 543 | 698 | 487 |
| Mean | 342 | 377 | 516 | 520 | 611 | |

LSD.05: Bread wheat - varieties NS, N rates 80 kg/ha, C.V. 19.91%
Durum wheat - varieties NS, N rates 95 kg/ha, C.V. 23.96%

Table A-15.
Mean fertility percentage of main florets over 4 replicates.

Dryland test, Brookings.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 98 | 97 | 98 | 96 | 96 | 97 |
| Penjamo 62 | 96 | 96 | 97 | 96 | 98 | 97 |
| SDI 6623 | 95 | 95 | 97 | 97 | 96 | 96 |
| Mean | 96 | 96 | 97 | 96 | 97 | |
| Leeds | 92 | 92 | 90 | 92 | 90 | 91 |
| SDI 669 | 88 | 89 | 91 | 88 | 93 | 90 |
| SDI 6617 | 91 | 92 | 93 | 92 | 92 | 92 |
| Mean | 90 | 91 | 91 | 91 | 92 | |

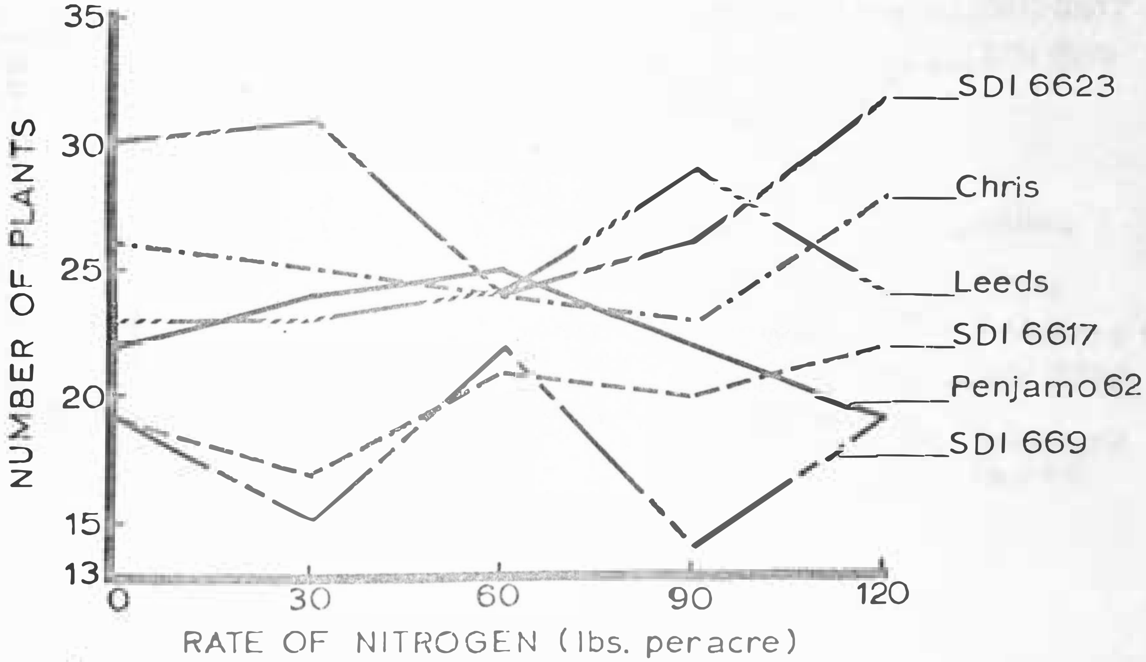
LSD.05: Bread wheat - varieties NS, N rates NS, C.V. 46.47%
Durum wheat - varieties NS, N rates NS, C.V. 19.32%

Irrigated test, Redfield.

| Varieties | Rates of N applied (kg/ha) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Check | 34 | 67 | 101 | 135 | |
| Chris | 98 | 98 | 98 | 98 | 99 | 98 |
| Penjamo 62 | 97 | 97 | 98 | 97 | 96 | 97 |
| SDI 6623 | 97 | 96 | 92 | 94 | 95 | 95 |
| Mean | 97 | 97 | 96 | 96 | 97 | |
| Leeds | 98 | 95 | 93 | 92 | 94 | 94 |
| SDI 669 | 95 | 98 | 95 | 94 | 96 | 96 |
| SDI 6617 | 95 | 96 | 95 | 97 | 94 | 95 |
| Mean | 96 | 96 | 94 | 94 | 95 | |

LSD.05: Bread wheat - varieties 0.34, N rates NS, C.V. 28.72%
Durum wheat - varieties NS, N rates NS, C.V. 31.94%

Figure A-1.




Number of plants from 60 cm., dryland, Brookings.

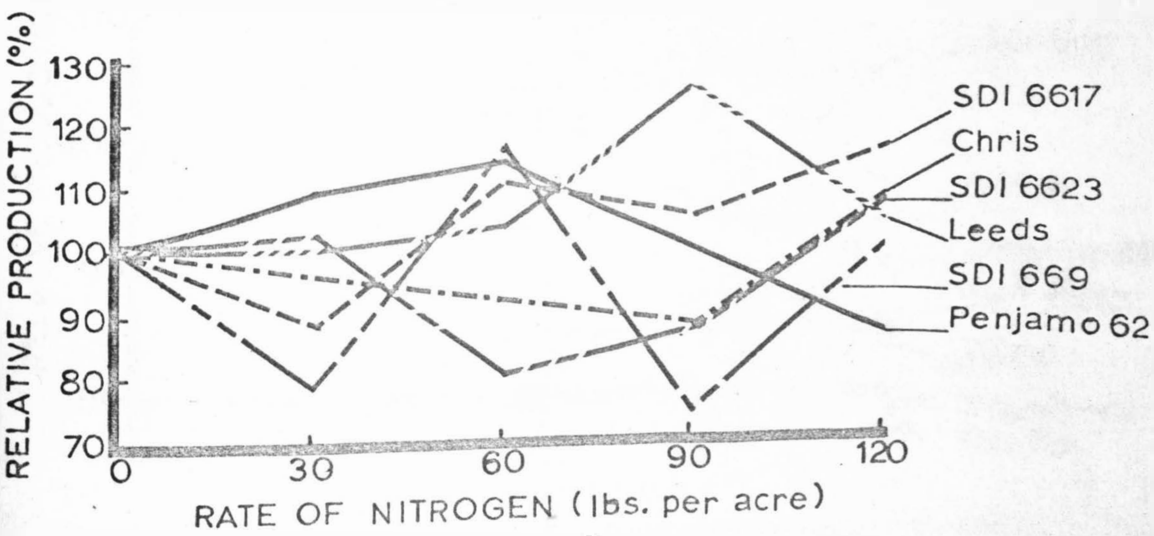
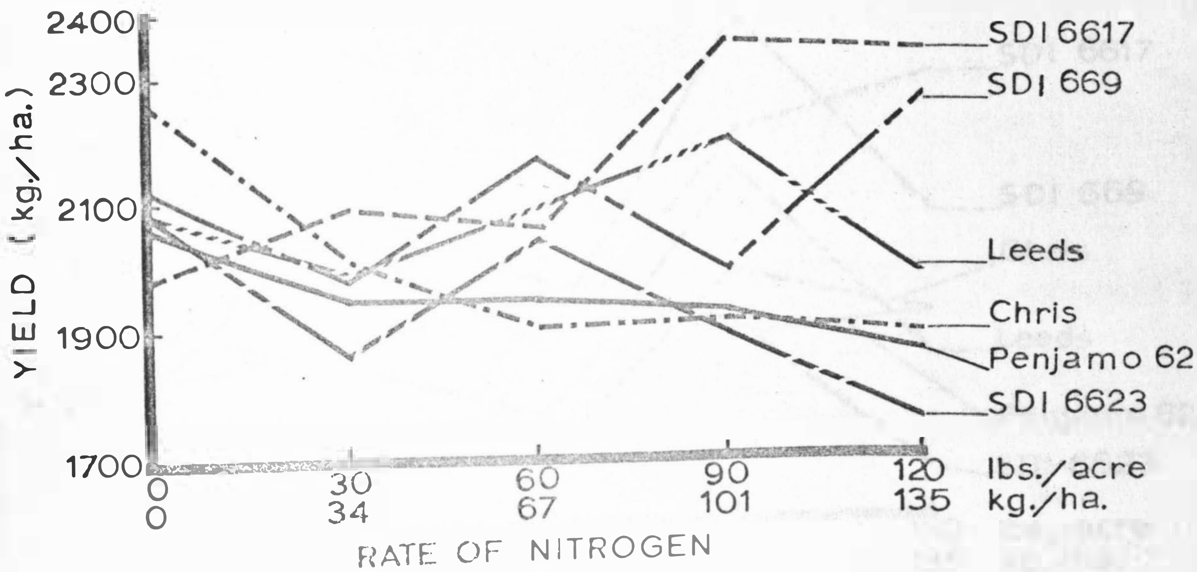


Figure A-2.




Grain yield from 60 cm., dryland, Brookings.

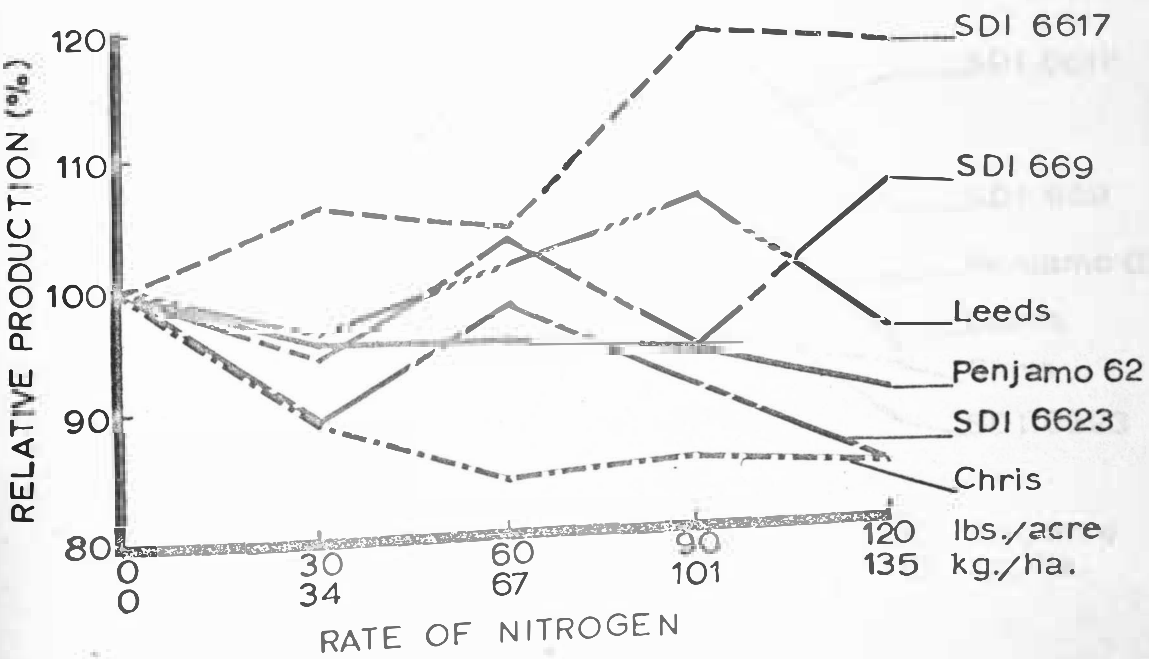
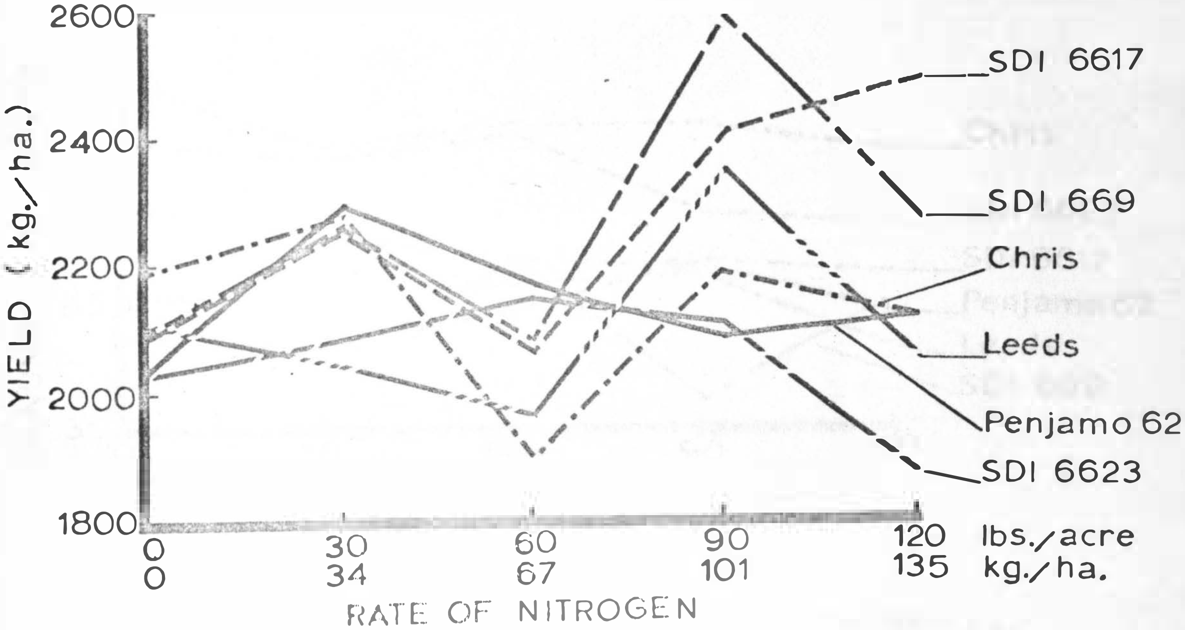


Figure A–3.




Grain yield from 180 cm., dryland, Brookings.

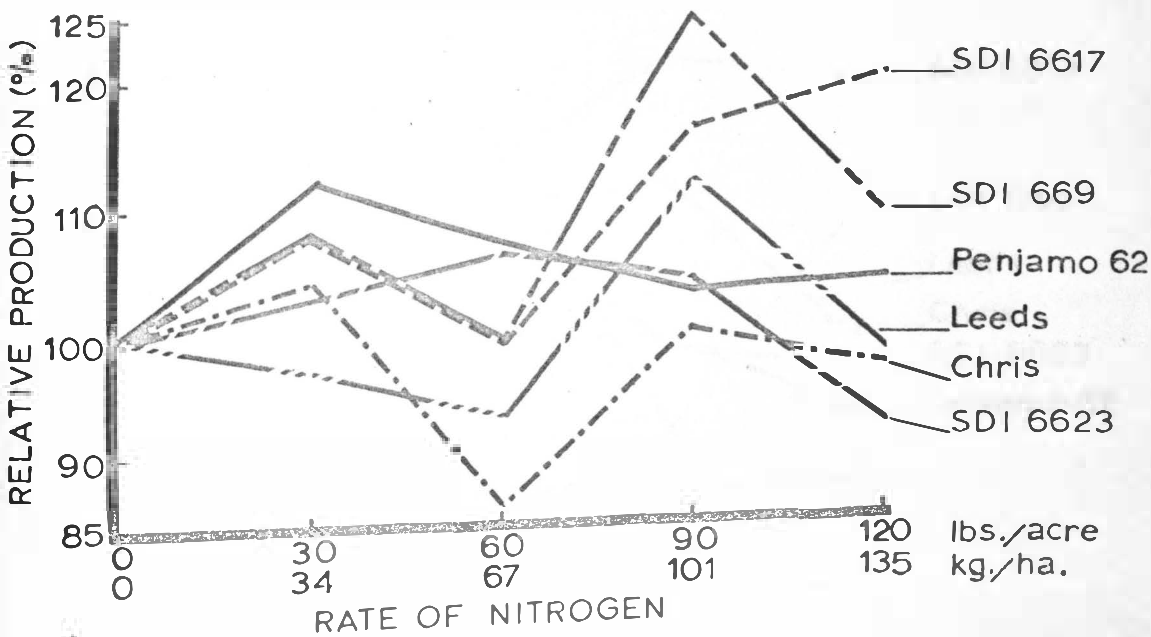
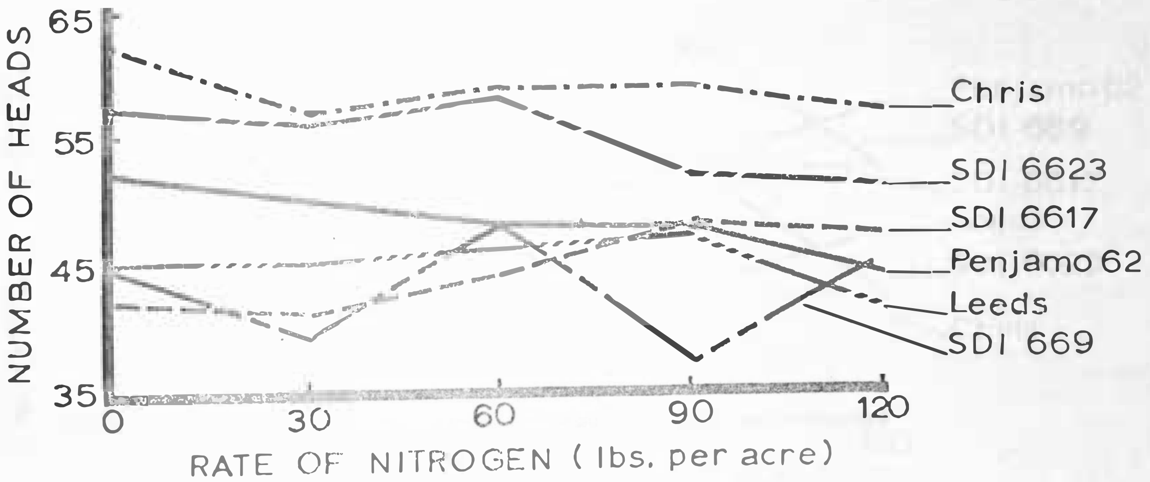


Figure A—4 .




Number of heads bearing seeds, dryland, Brookings.

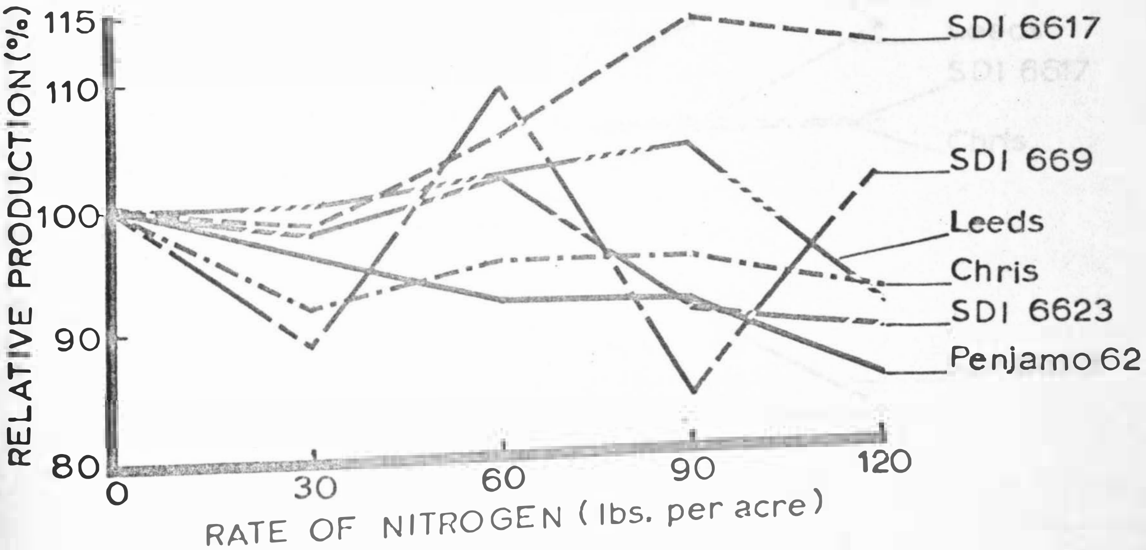
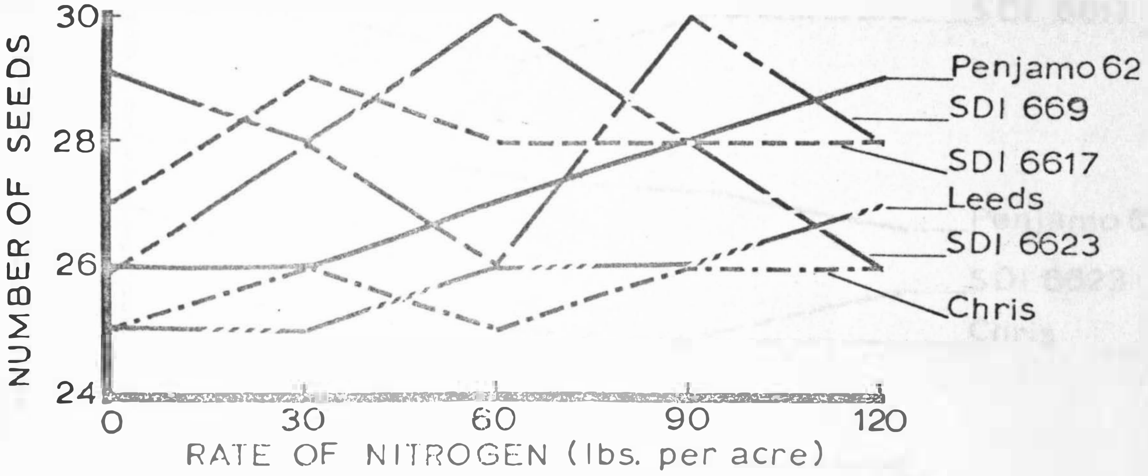


Figure A–5.




Number of seeds per head, dryland, Brookings.

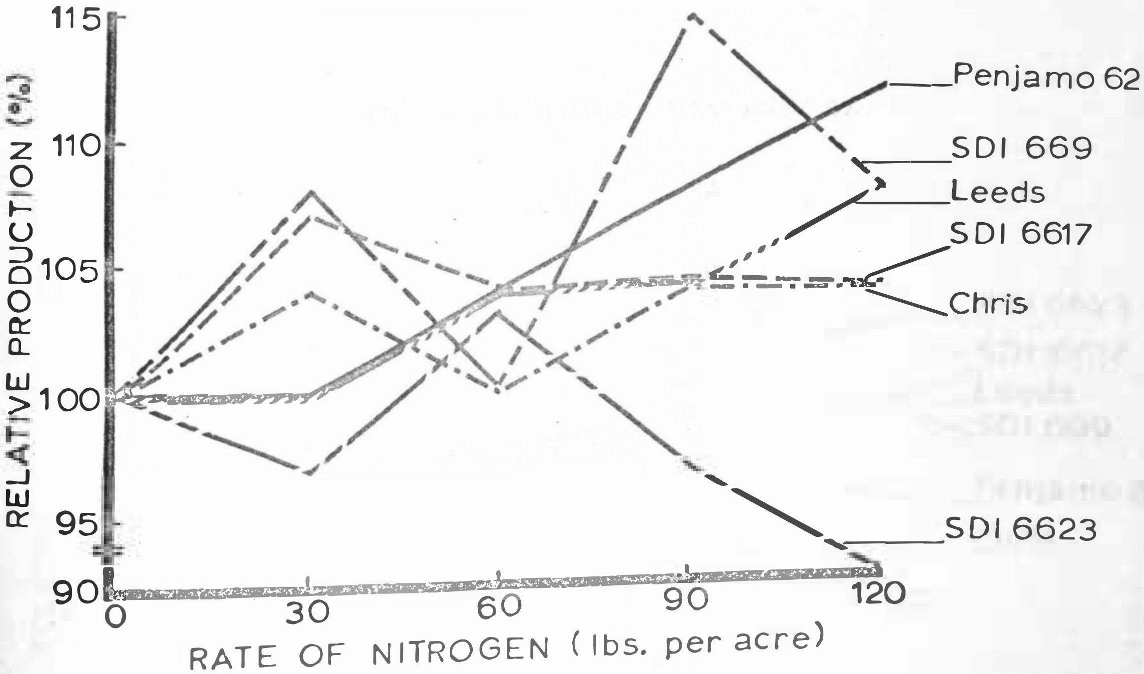
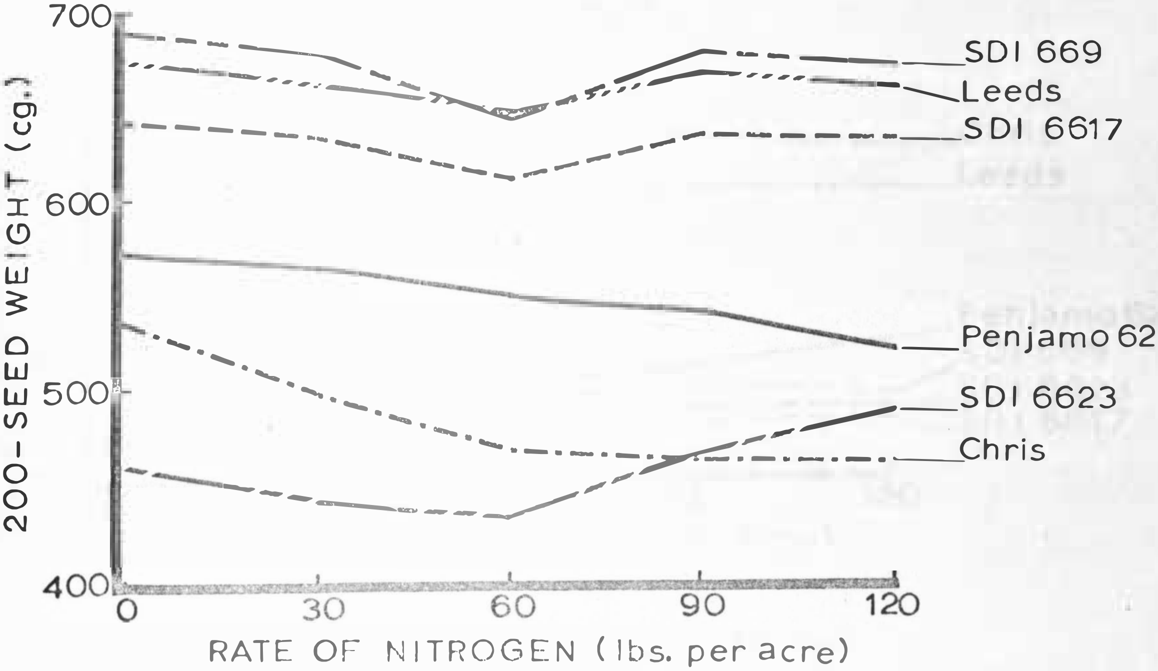


Figure A–6.




200-Seed wt., dryland, Brookings.

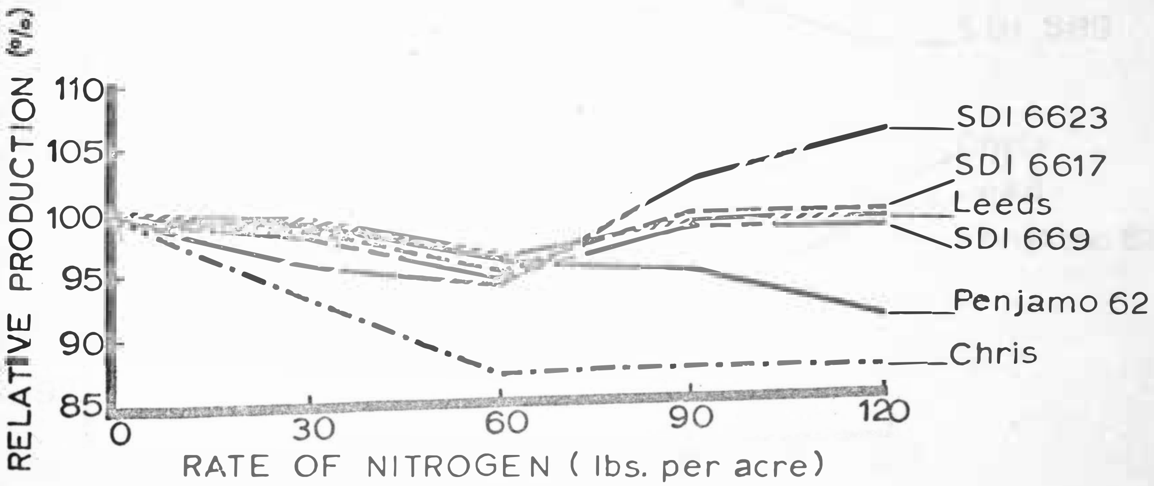
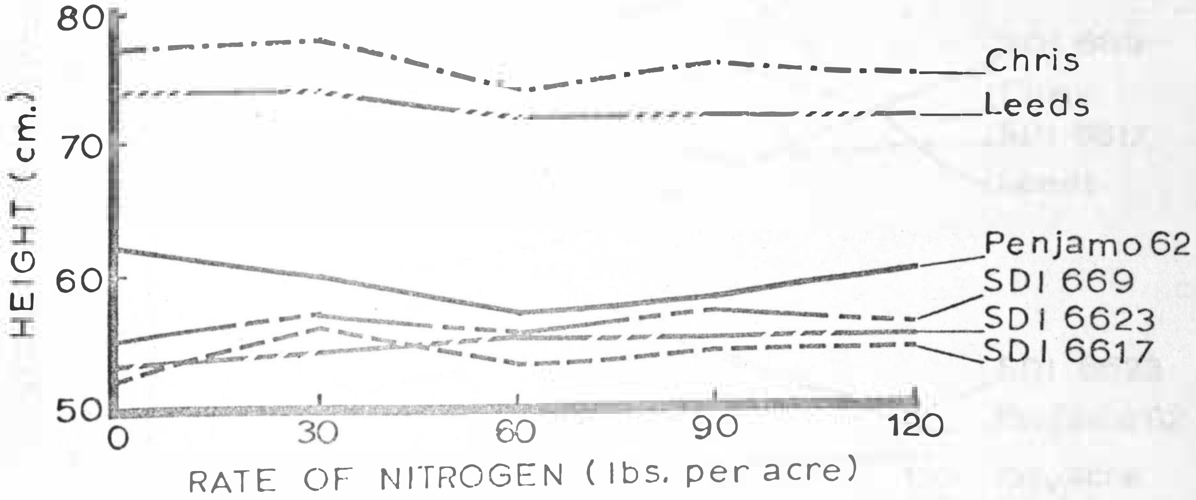


Figure A-7.




Height, dryland, Brookings.

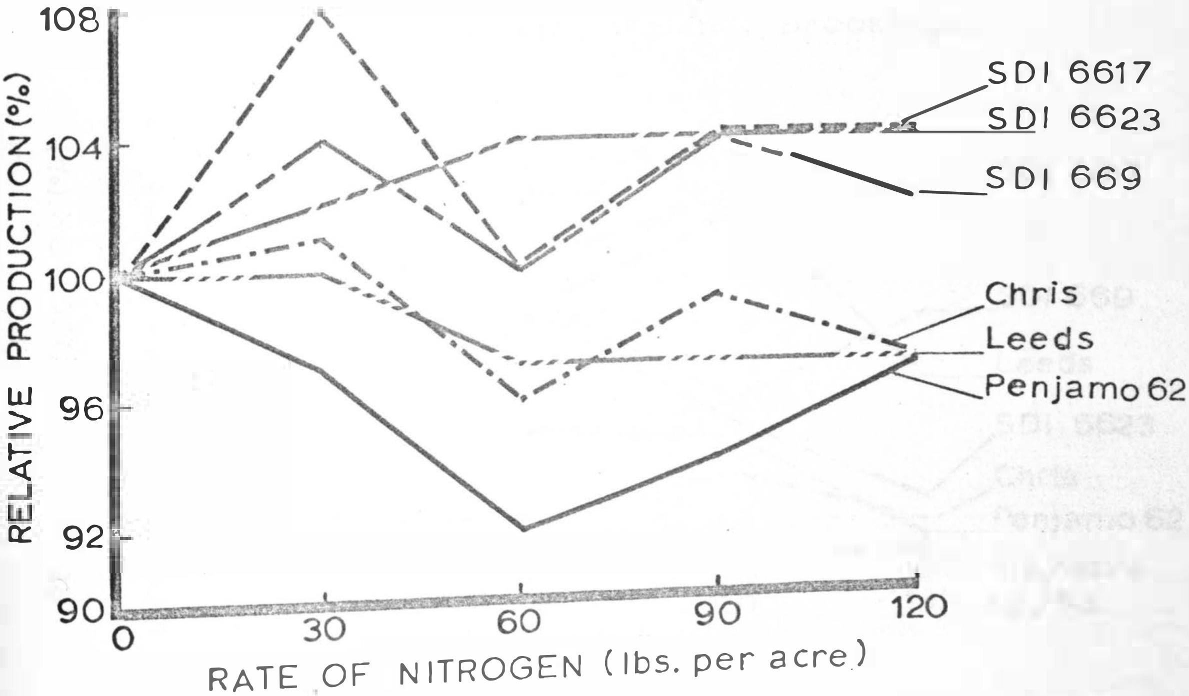
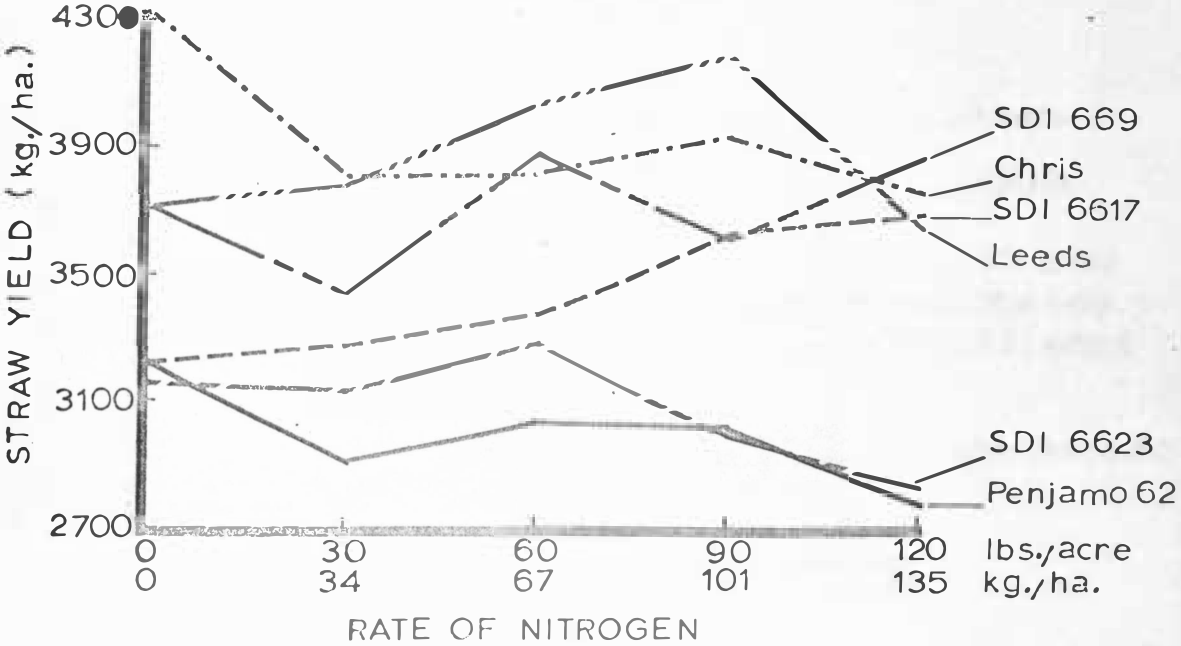


Figure A—8.




Straw yield from 60 cm., dryland, Brookings.

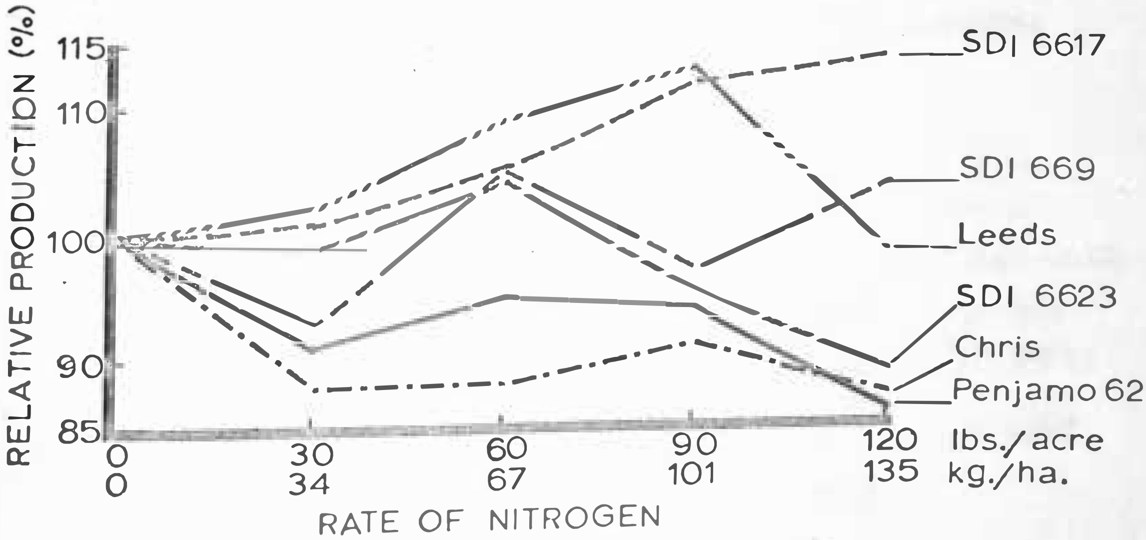
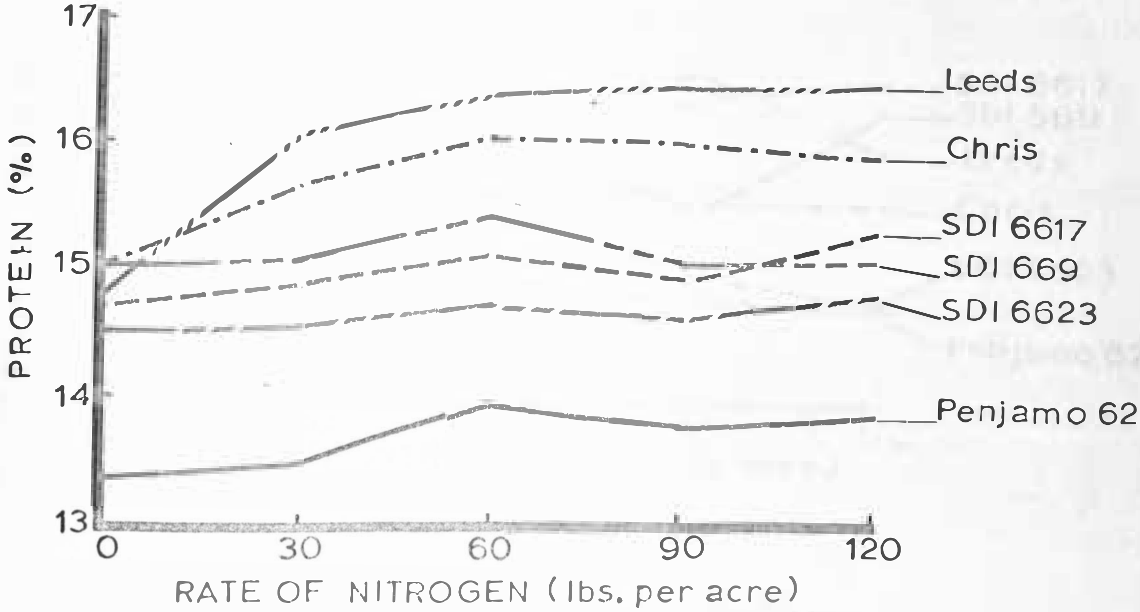


Figure A-9 .




Protein percentage , dryland, Brookings.

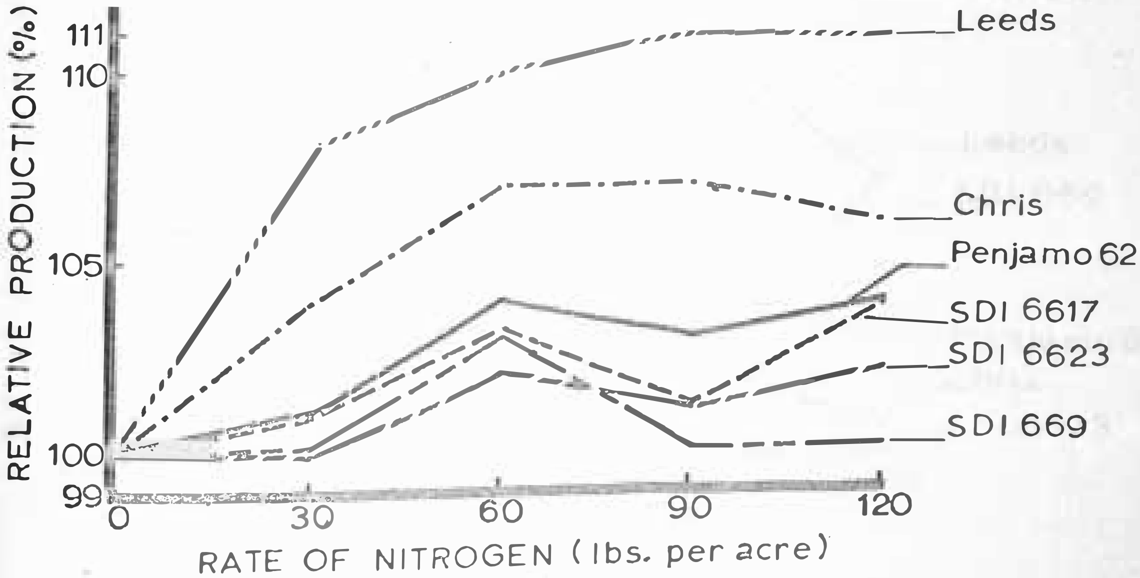
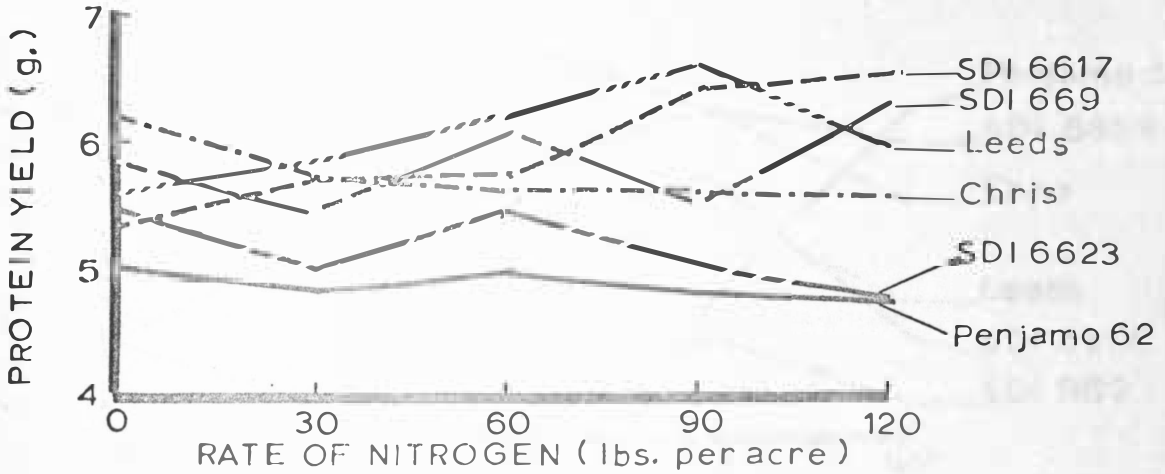


Figure A—10.




Protein yield, dryland, Brookings.

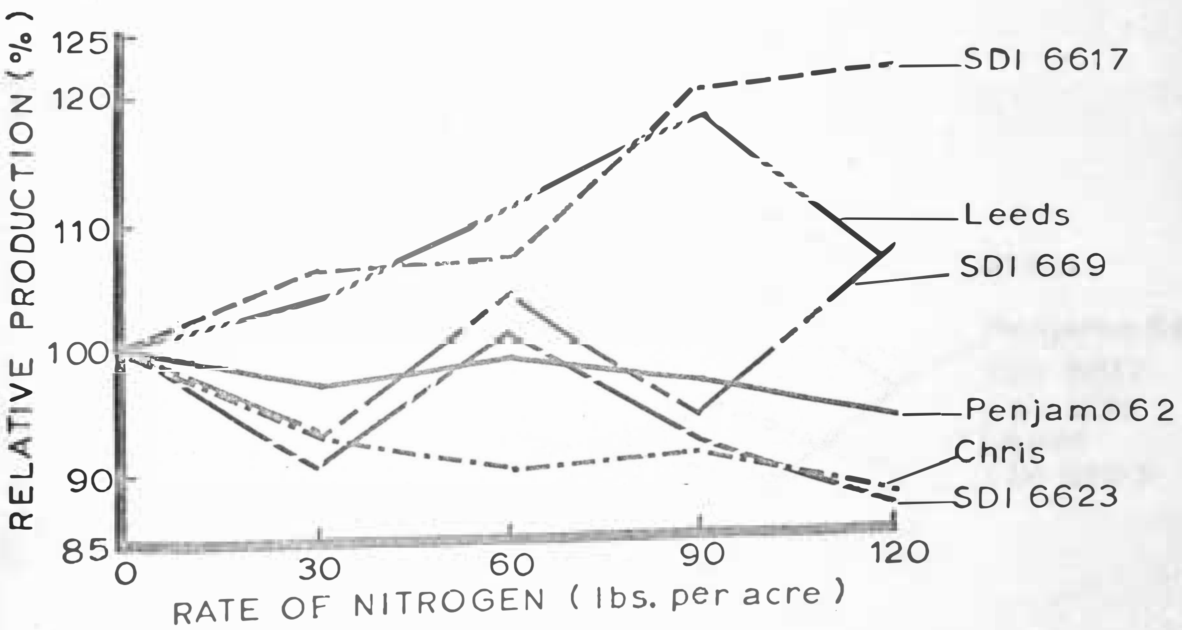
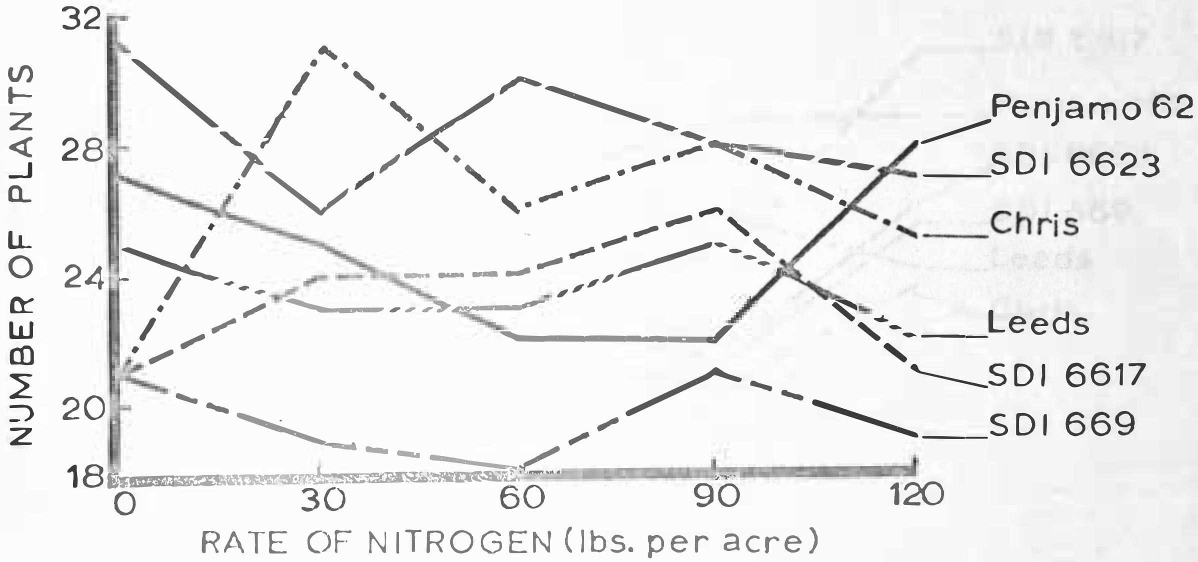


Figure A—11.




Number of plants from 60 cm., irrigated, Redfield.

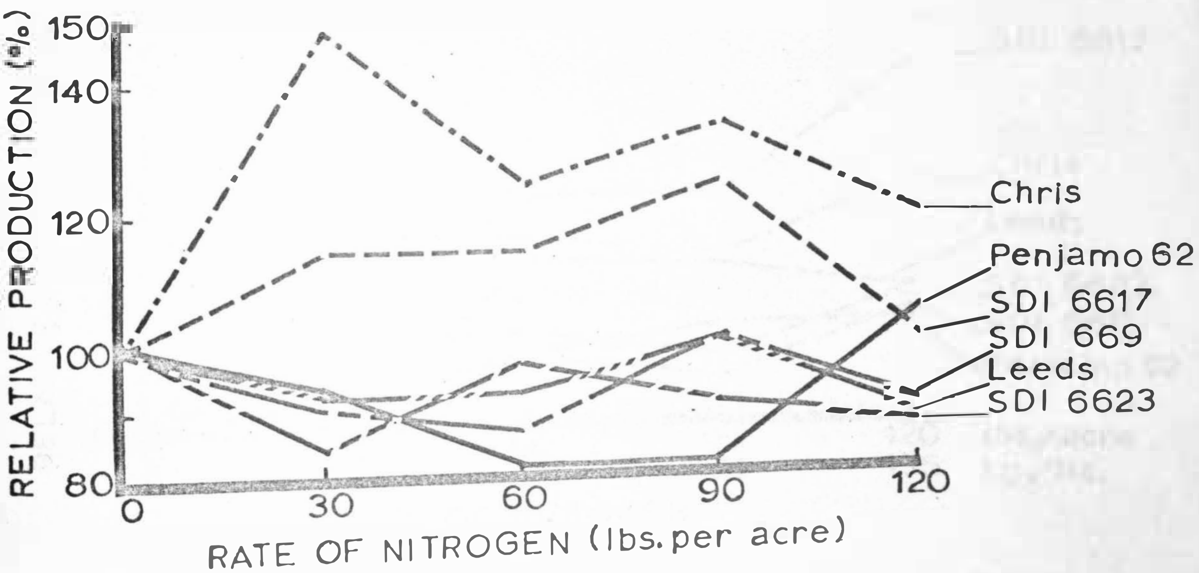
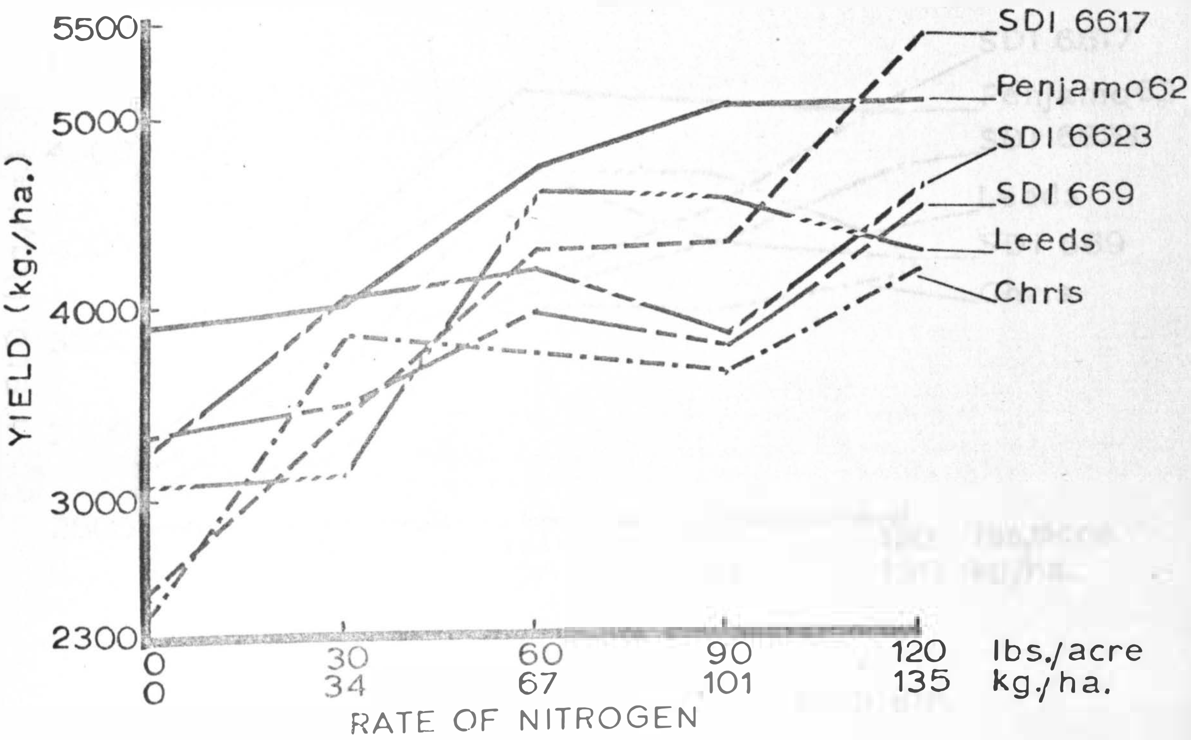


Figure A-12.




Grain yield from 60 cm., irrigated, Redfield.

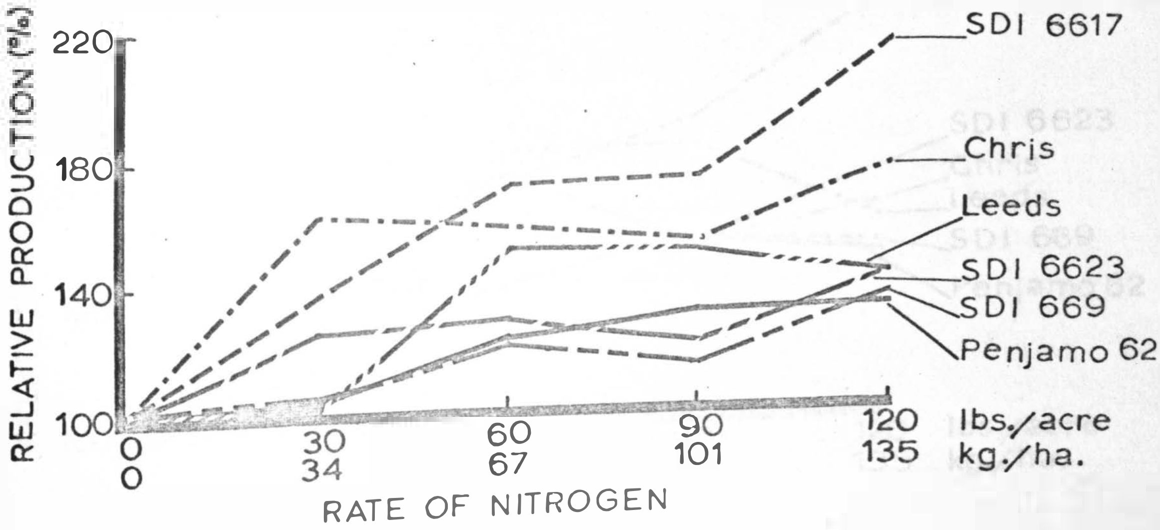
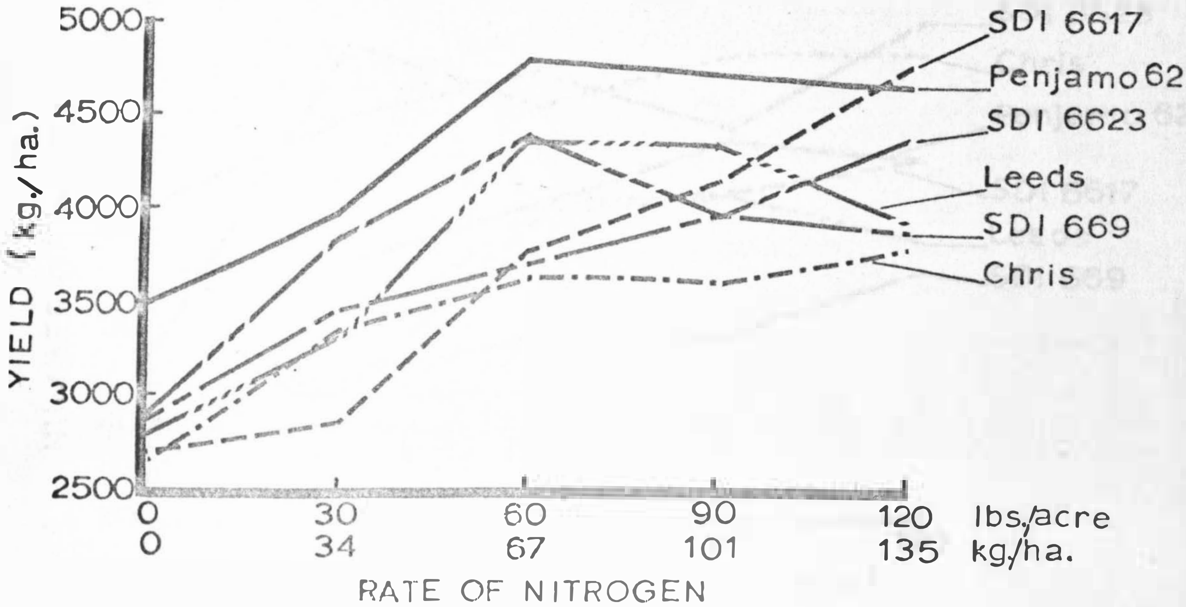


Figure A—13.




Grain yield from 180 cm., irrigated, Redfield.

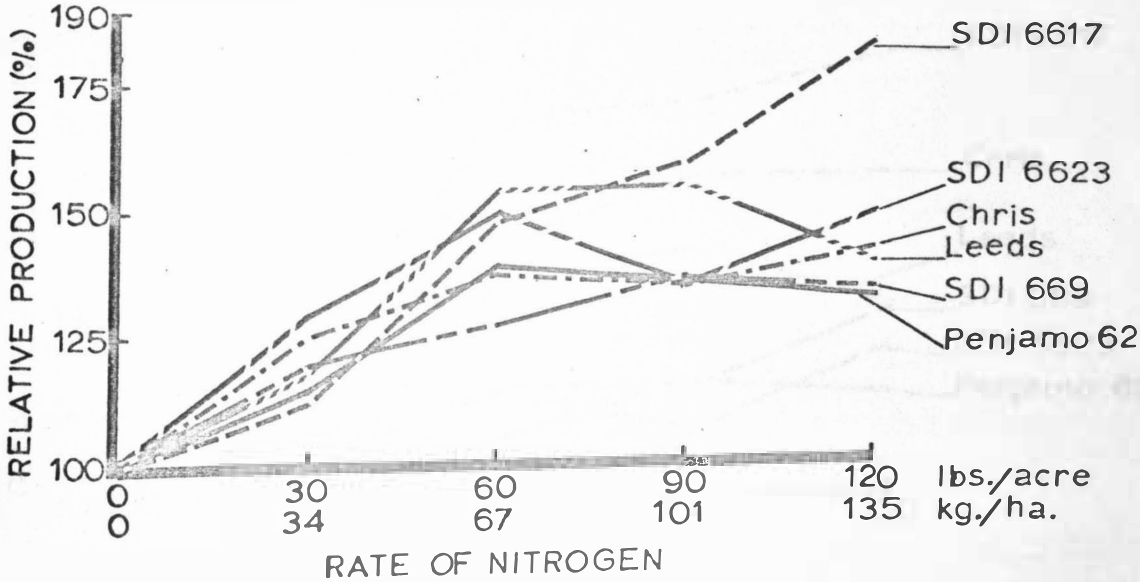
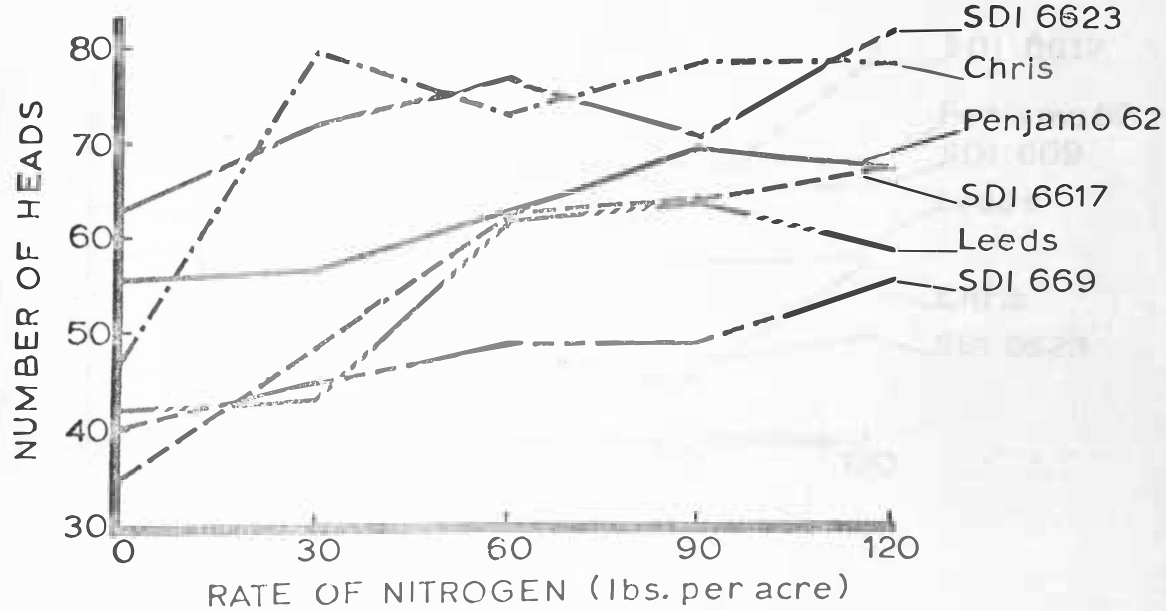


Figure A-14.




Number of heads bearing seeds, irrigated, Redfield.

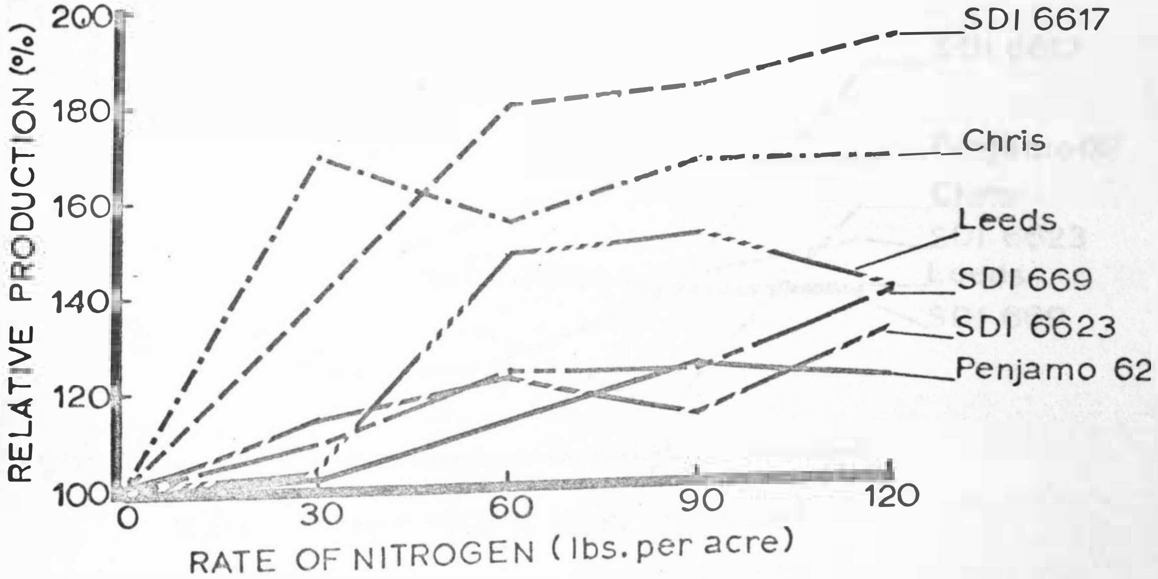
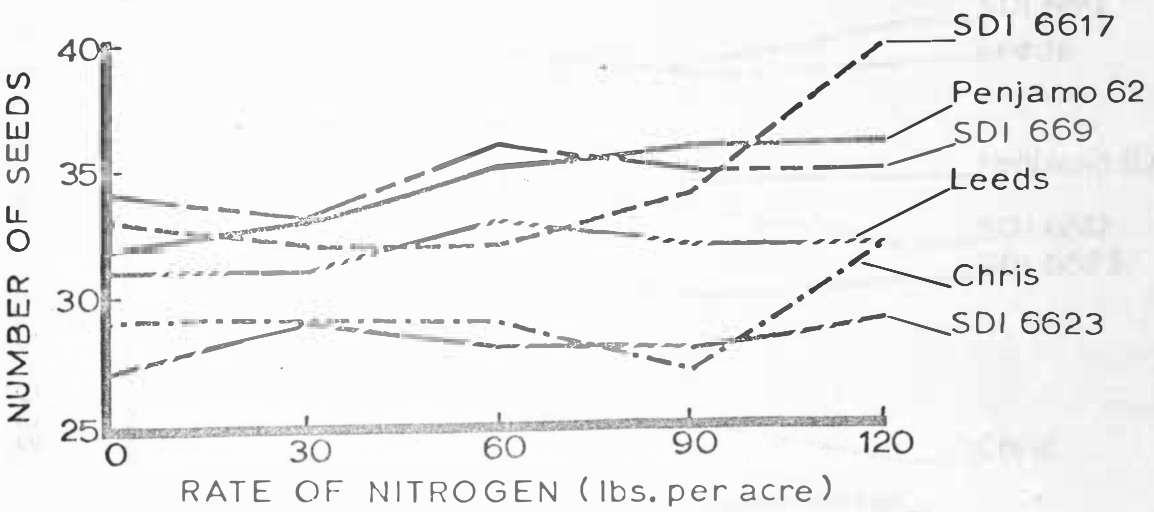


Figure A-15.




Number of seeds per head, irrigated, Redfield.

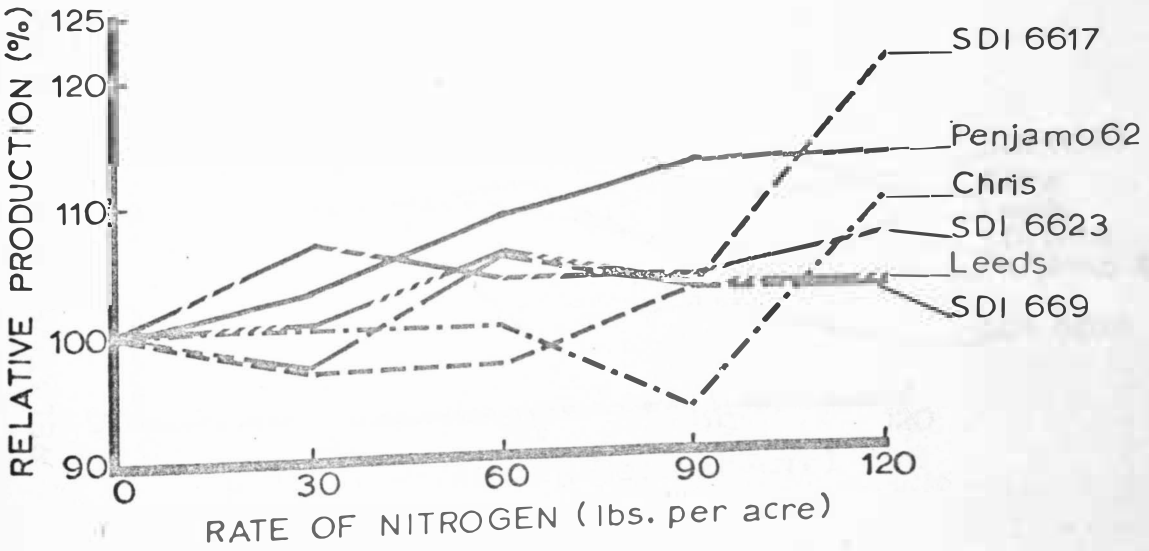
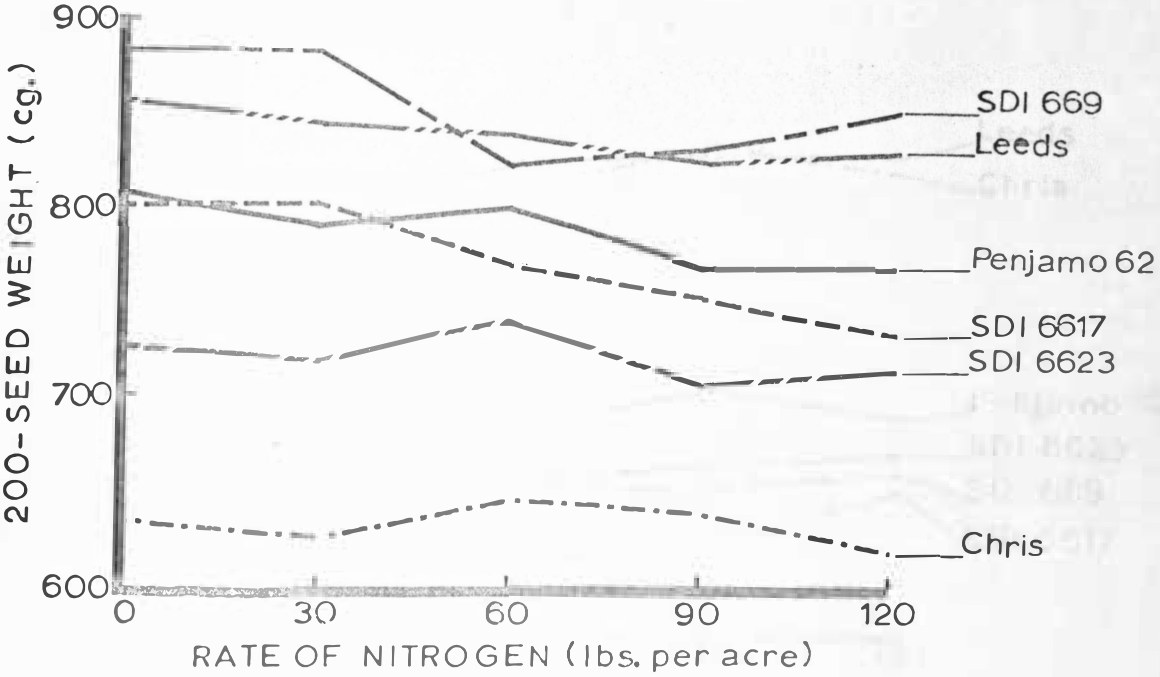


Figure A-16.




200-Seed wt., irrigated, Redfield.

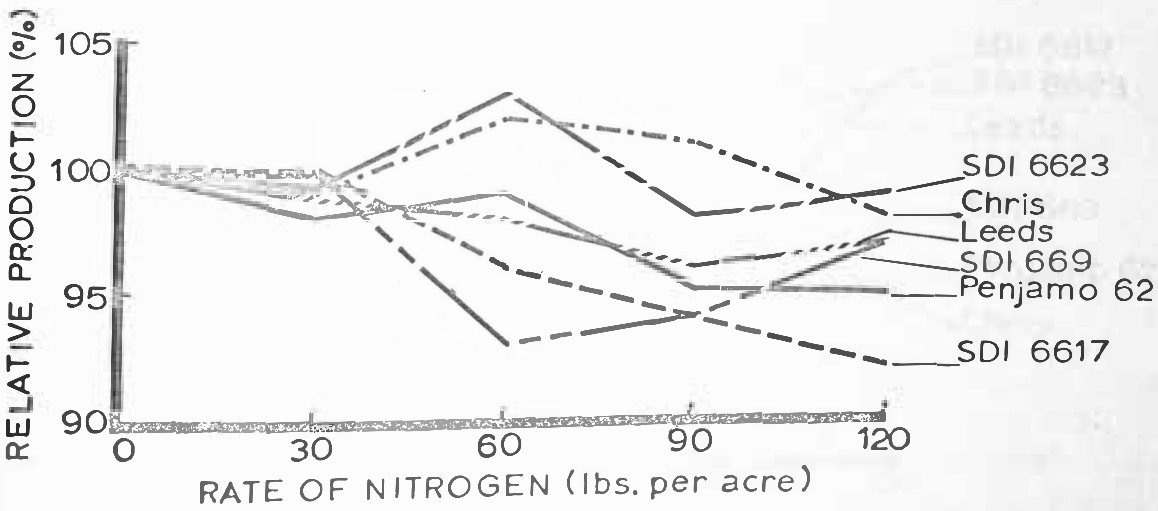
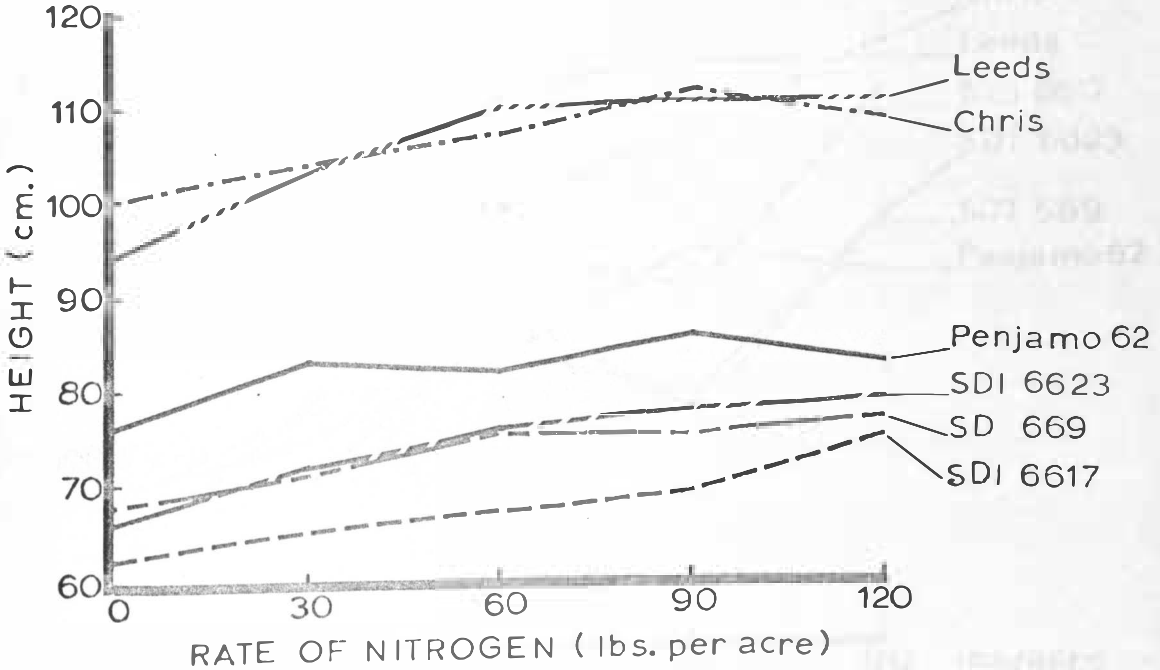


Figure A–17.




Plant height, irrigated, Redfield.

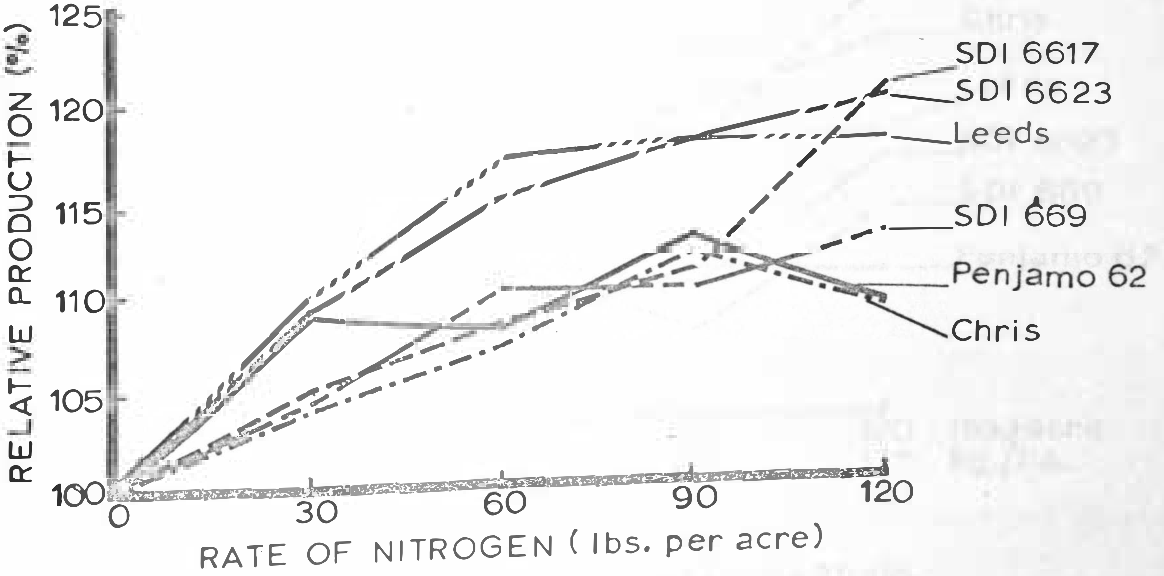
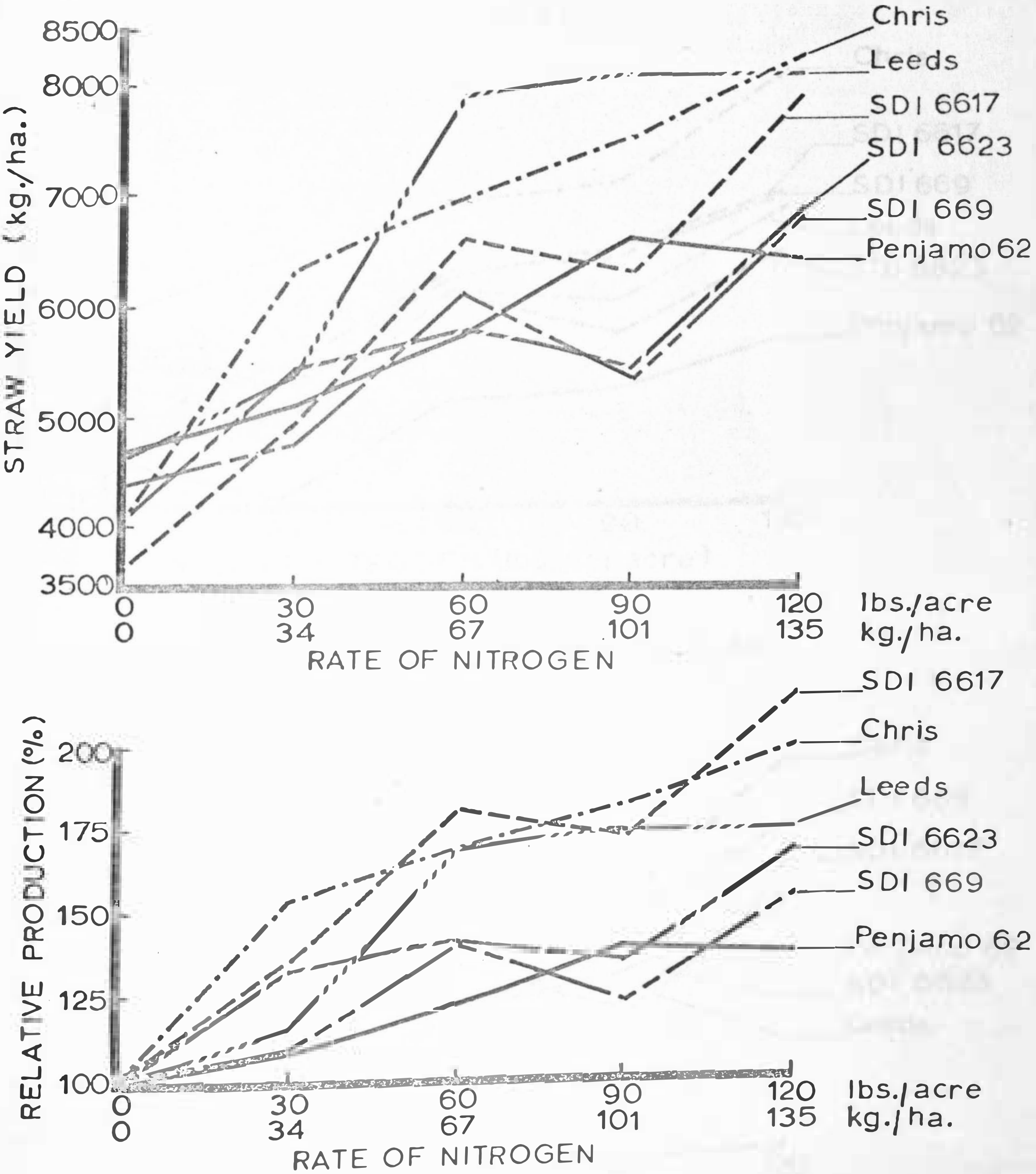
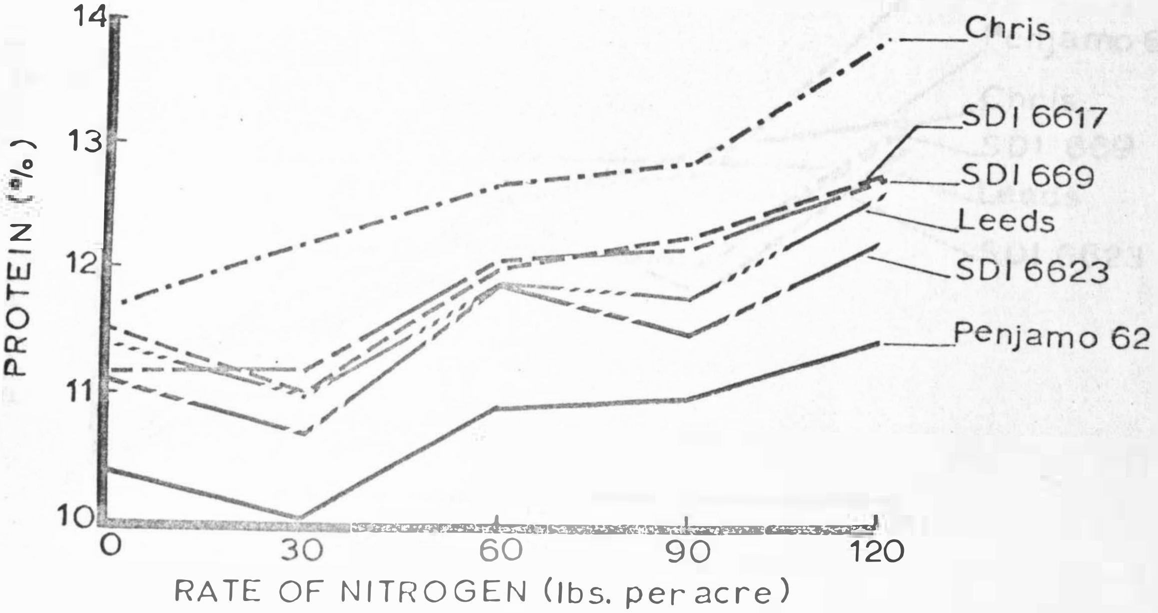


Figure A—18.




Straw yield from 60 cm., irrigated, Redfield.

Figure A—19.




Protein percentage, irrigated, Redfield.

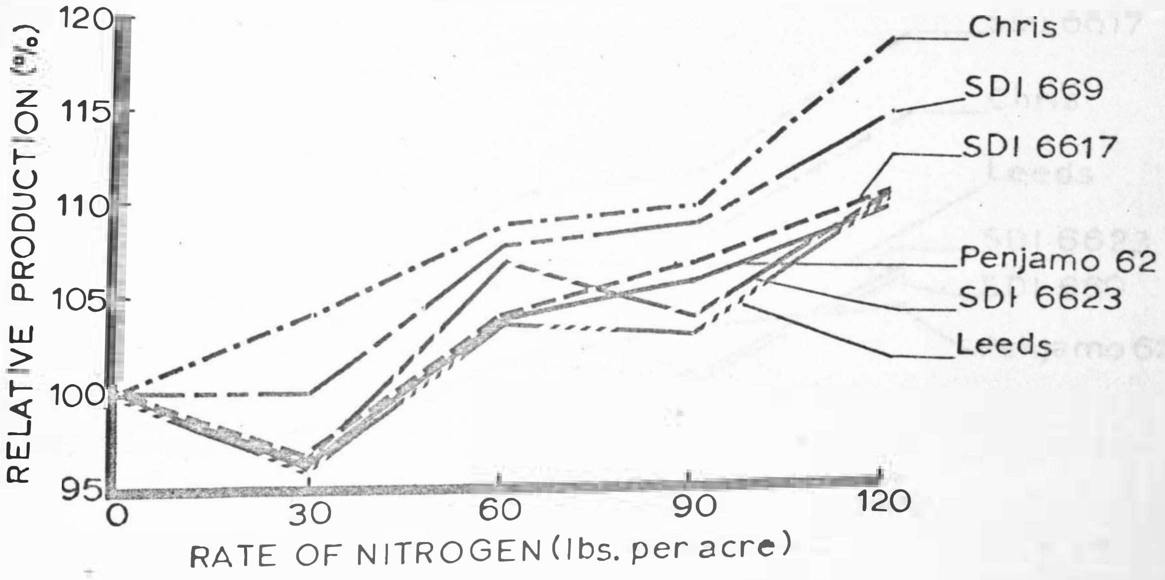
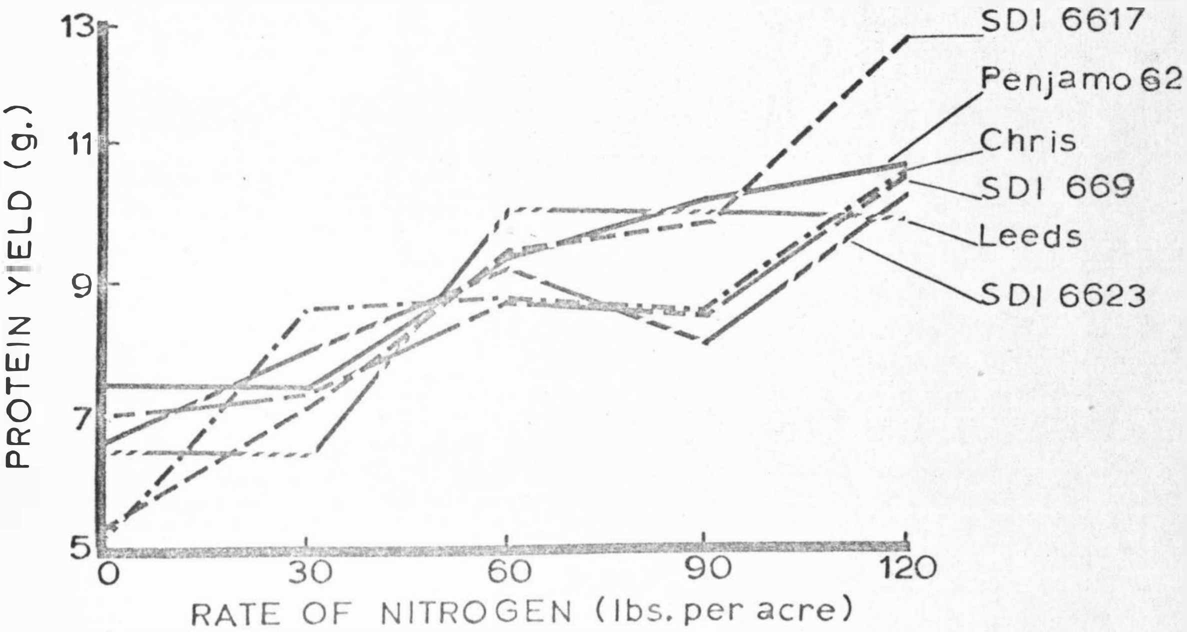


Figure A—20.




Protein yield, irrigated, Redfield.